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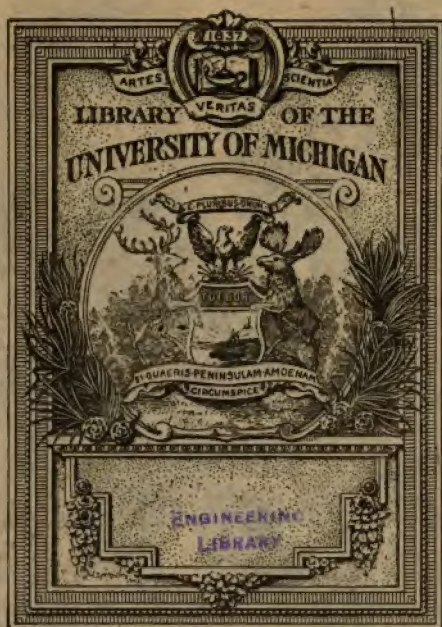
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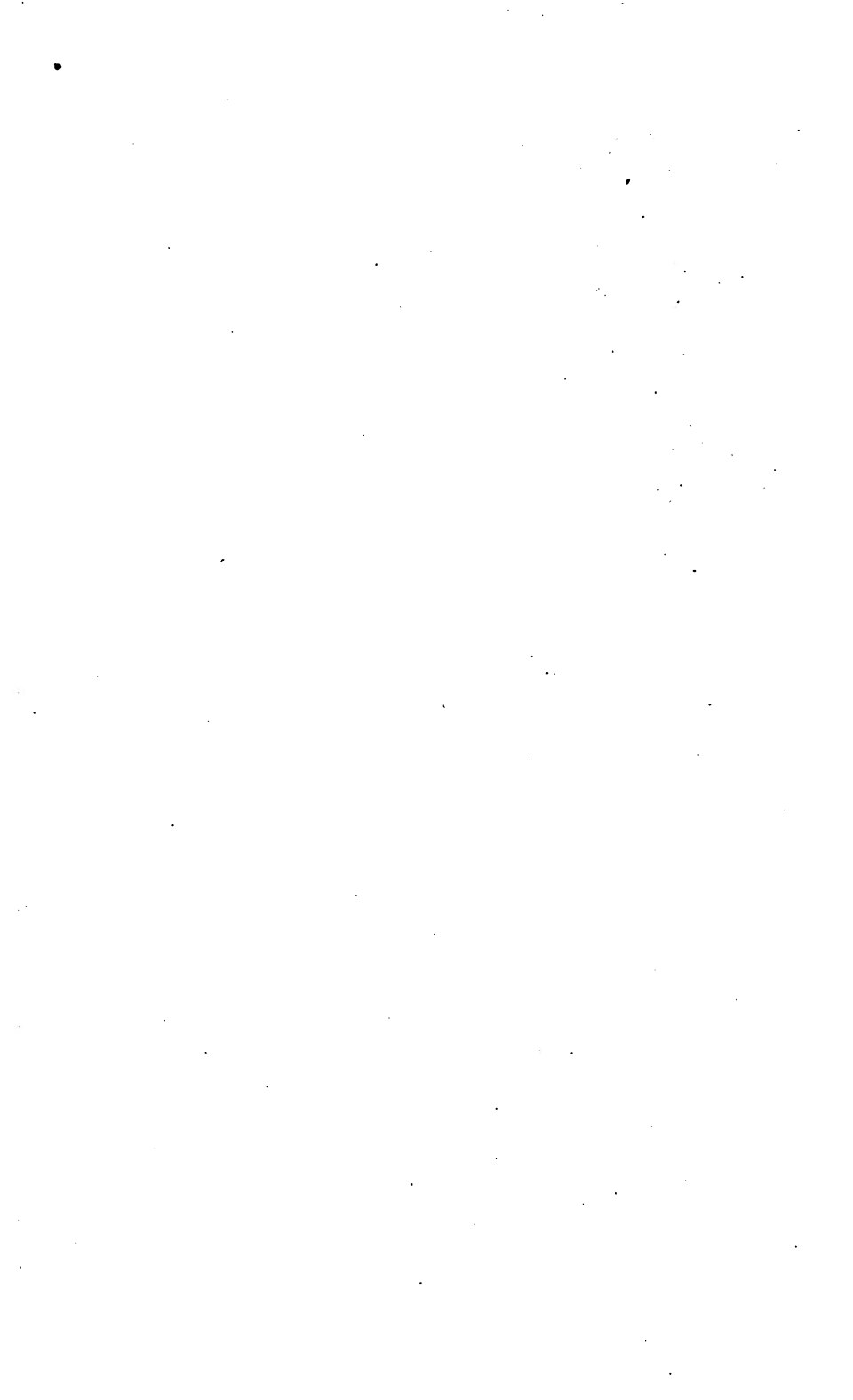
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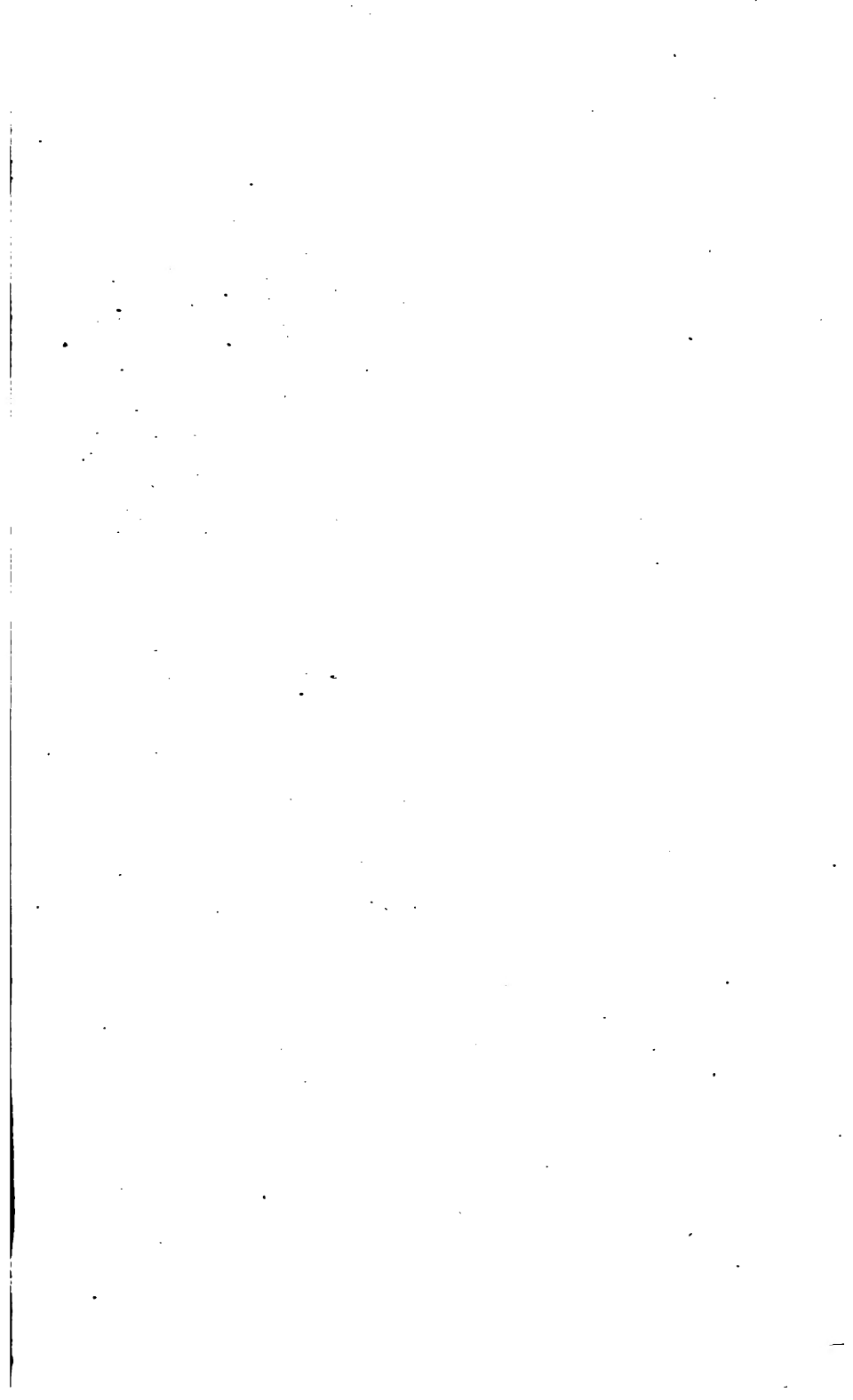














# TRANSACTIONS

OF THE

## INSTITUTION OF CIVIL ENGINEERS



OF

IRELAND,

LONDON

FIFTY-FIRST SESSION, TO JUNE, 1886.

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VOL. XVII.

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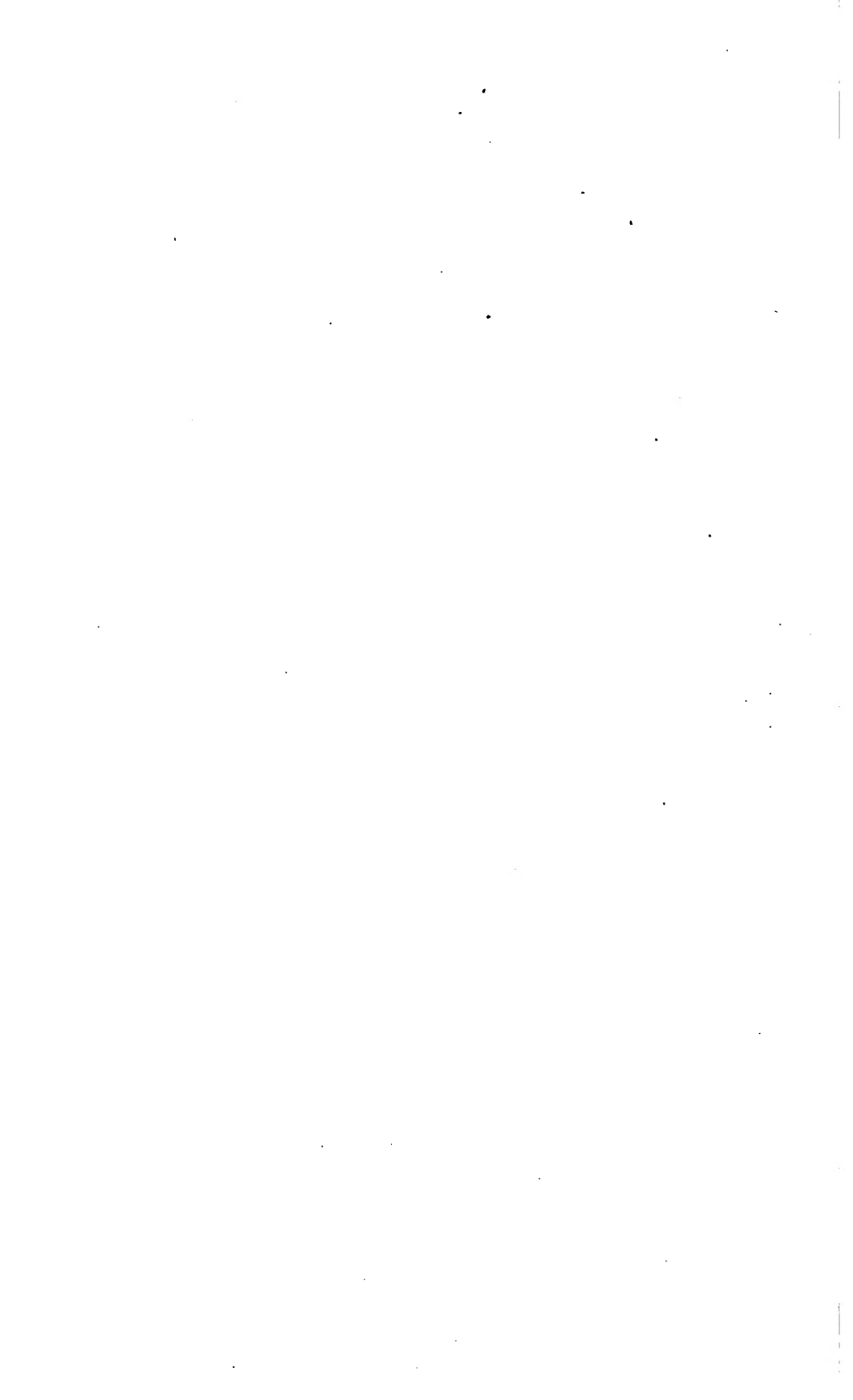
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TRANSACTIONS  
OF  
THE INSTITUTION OF CIVIL ENGINEERS  
OF IRELAND.

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[4th November, 1885.]

J. A. F. ASPINALL, President,  
in the Chair.

The following Candidates were balloted for and duly elected, viz:—

ARTHUR GORE RYDER and HENRY THOMAS HARTON,  
as Associates.

The PRESIDENT then delivered his Address as follows:—

GENTLEMEN,

I have again to thank you for the honour which you did me last year in electing me as your President—an honour which I appreciate more when I reflect that this Institution was founded in 1835, and had then for its President so illustrious a man as Sir John Burgoyne.

During the past session we have had brought before us papers of an interesting and valuable character, upon widely different subjects, having thus the advantage of affording useful information to each class of members of this Institution.

It is my intention to mention briefly this evening a number of subjects connected with modern engineering work, rather with a view of suggesting to the minds of some of our members

that they could select one or two of them upon which to write papers which would add to our general knowledge.

If I deal with subjects more immediately connected with Mechanical Engineering, and, therefore, perhaps not of so much interest to some of our members. I must ask you to remember that this is the class of work with which I am more familiar.

I would direct your attention to the way in which the use of steam power for working tramways has grown within the past five years, and it is no doubt due in a great measure to greater perfection in the construction of the engines, which have been made not only less noisy and so less likely to frighten horses, but also to the fact of their being made with working parts having larger bearing surfaces which tend to keep the engine out of the repair shop for a longer period, and thus reduce the cost of maintenance. It is remarkable how around Birmingham and in Leeds, where tramway engines are extensively used, the horses seem to have got accustomed to them, and take no notice of them. The cost of working per mile run is given at 4·78d. for Birmingham and at 6·4d. for the Dudley and Stourbridge lines.

The general result of the improvement and experience in the construction of tramway engines will be apparent to those companies who have taken advantage of recent legislation to construct tramways in this country, though it is unfortunate that so many of them have fallen through, in cases where their construction would have been an undoubted advantage. In connection with this subject I would draw attention to a matter which I have previously mentioned in this room, and that is, the desirability of some definite rules or recommendations being drawn up by the Board of Trade as to the construction of tramway rolling stock to be used upon Irish tramways. There are now no rules as to the height of the carriages, the height of floors, the method of coupling, or the

height of buffers, or any of those dimensions which have been well worked out for ordinary railways, and have been adopted with common consent by all the companies, so that their stock may be run on each other's lines.

Every maker of tramway stock at present adopts varying designs for his vehicles, which in the future will no doubt be found to cause endless trouble. A first-rate example of tramways constructed to feed a railway will be found in the Wisbech lines running in connection with the Great Eastern Railway. In this case the rolling stock, although of the tramway type, has been constructed to run in with the ordinary stock of the parent line. The carriages have a central passage, and the engines are thoroughly well designed and constructed.

Another form of tramway engine is that worked with compressed air on Mekarski's patent. Those which have been running at Nantes for some years have the engine attached to the car, which weighs 6 tons empty and 8 tons when filled. The reservoirs carry 220 lbs. of air, at a pressure of over 400 lbs. per square inch. The consumption of air per mile is given at 25·9 lbs., and the cost of working at 5·89d., which is somewhat less than I have quoted for the steam tramway engines, but these figures should not be compared without some knowledge of the respective localities through which they work.

The cable system of tramways now in use at Highgate has been most successful in San Francisco, where it originated, and seems to be peculiarly applicable to towns where there are heavy gradients, and where horse traction becomes impossible. The arrangements for carrying the cable under ground for guiding it around curves, and, finally, for gripping it by the grip attached to the tramcar are all of an ingenious character.

The several systems I have mentioned, all of which are making progress, are indications of the growing popularity of



introducing some form of mechanical power for working tramways. The electric tramway at Portrush, and the one from Newry to Bessbrook, are further instances of the same kind, though they partake more of the character of a railway.

When looking to see what advance has been made in the construction of locomotives we find that upon all the greater lines in England the demand for high speeds, together with an increase of loads has led to a gradual increase in the power of the engines which have to do the work. On the Midland Railway of England engines for express work have now cylinders 19 inches diameter by 26-inch stroke, while on the London and North Western Railway a more powerful engine has been obtained than they hitherto had by the introduction of Webb's compound system. The most recent engines of this type have a 30"  $\times$  24" low pressure cylinder between the frames and two 14"  $\times$  24" high pressure cylinders outside the frames. The engine is made almost wholly of steel, and many parts hitherto built up of angles and plates, or forged under the hammer, are made of cast steel, a material coming largely into use for such special work, now that some of the many difficulties of producing sound castings have been overcome. The boilers of these engines carry a higher pressure than was used before compounding was introduced, thus enabling a greater grade of expansion to be used with the increased cylinder capacity. The higher pressure is in itself a source of economy when we consider the very small additional amount of heat required to produce an increase of pressure over and above the ordinary pressure previously used in locomotives.

These engines must be looked upon as economical machines by the London and North Western Railway, if one is to consider a large increase in their number as being evidence of satisfactory results.

On the Great Eastern Railway a number of compound

locomotives of somewhat different type have been built by Mr. Worsdell, who has so arranged that one pair of cylinders should do the work, and that the ordinary form of crank-axle should be retained. In fact, he has followed Mallet's practice. The diameter of the low pressure cylinder is 26" and that of the high pressure 18". The economy of fuel said to be obtained by the first of these engines has led to a number of others being built.

On another English railway a compound locomotive with four cylinders is being constructed. In this case the cylinders are of the tandem type, but the working results are not yet known.

It is somewhat remarkable that the experience of Mallet, in France, who has long been in the habit of using the compound locomotive with two cylinders, and of Herr Von Borries, in Germany, should not have earlier led to the introduction of the system into England, when both these authorities claimed an economy of from 18 to 20 per cent.

A leading bogie for passenger locomotives has now become almost universal, those railways who do not use it having in most cases adopted some form of radial axle-box, so as to ensure the necessary amount of flexibility in the wheel base. For branch lines and suburban traffic a tank engine having four wheels coupled with a radial axle-box in front and one behind is now not at all uncommon.

The adoption of the bogie truck for carriages which the Americans have used so long has been gradually extended since the introduction of the Pullman cars on the Midland Railway, and though the American pattern of body, with a central passage, has not been copied, the bogie has found the greatest favour, and there are hardly any of the larger companies which do not build a proportion of their stock with bogies.

In one notable instance, however, a form of radial axle-box

has been used in preference to bogies, though the length of carriage is about the same.

The efforts of locomotive engineers have constantly been directed to effect every possible saving in fuel, which is one of the most serious items of locomotive expenditure on railways, and the success they have obtained is seen upon the chief lines, where train loads of greater length and much greater weight are being hauled with a consumption of fuel which does not exceed that of 15 or 20 years ago, and is in some cases actually less. When speaking of the consumption of fuel, I am naturally led to think of the remarkable absence of coal from this country, and the cost of obtaining it from elsewhere. The carriage across channel of coal purchased in England adds very largely to its original cost, and this becomes a serious tax upon any manufacturing industry.

It is true that a certain amount of coal can be obtained here, but the supply is very limited and the class of coal is not one suitable for all kinds of work.

I have used and am still using coal from the Athy collieries, and it may be of interest to you to know that it is an anthracite coal of good quality.

Experiments, by which I have tried to compare it with other steam coals, show that 8·12 lbs. of water can be evaporated per lb. of coal, which is a good result. It is, however, peculiar and breaks up into very small particles when in the fire, which renders it necessary to have the firebars extremely close so as to avoid loss. Further than this it rapidly burns out the ordinary form of firebar, and if used exclusively it would be necessary to have specially constructed fire-boxes suitable for taking water firebars. Mixed, however, with Welsh coal it does very well in the ordinary locomotive grate.

One is often asked why in a country where so much turf is to be found that it is not used upon the railways, but I would point out that it has been tried repeatedly, and with very

great care, by those who were deeply interested in the subject without any real success. The supply of cut turf is too dependent upon good seasons to be relied upon, and even if it could be supplied with regularity, it will not stand the punishment in the fire-box to which ordinary coal is subjected when burning in a locomotive drawing a heavy train. If, however, the turf is compressed and well dried it makes a fairly good fuel, but no efforts to produce it in this form have been commercially successful, and the history of the failures of the numerous peat works which have been started would fill many pages. The evaporative efficiency of good compressed peat being only about one-half that of coal, it follows that the price must be in about the same proportion, and this has been the difficulty. A paper was read before you in 1874 which goes fully into this subject.

In America, where coal abounds, petroleum has begun to displace it as a cheaper fuel, and in Russia the locomotives on the Grazi-Tsaritsin Railway have for some time been fired with nothing but petroleum.

Mr. Urquhart has done a great deal to bring about its successful use for locomotives, and it is quite possible that economical methods of transport may make it the fuel which can be used with good results on our own railways and in the furnaces of our manufactories.

On one of the American railroads where petroleum has been burnt in locomotives, it is stated that one gallon of petroleum is found equal to 175 lbs. of the best bituminous coal; and another company owning large ferry steamers state that they find petroleum about 50 per cent. cheaper than coal, and point out the rapidity with which steam can be got up by its use, and the ease with which fires can be lighted and put out in all or any of the boilers in a few seconds.

Though we have not the oil wells of America, our chemists have shown that vast quantities of oil suitable for many

purposes, including the firing of boilers, have annually been wasted at our blast furnaces, and I should not omit to mention the great results obtained in this direction at Gartsherrie. It has been computed that if all the Scotch blast furnaces were to follow the example of Gartsherrie in utilising their waste gases, 7,360,000 gallons of oil would annually be produced in addition to large quantities of other valuable products.

The importance of the question of using liquid fuel is rapidly forcing itself to the front, and if the statement which I have quoted above be correct, that 1 gallon of petroleum, or about 10 lbs., will do the work of 175 lbs. of coal, the mere question of weight to be saved will have serious influence on its use in steam ships.

The Gartsherrie Iron Works, which I referred to above, have been able to turn out a very large quantity of creosote oil at a price which has had an appreciable effect on the value of oil produced from ordinary gasworks tar. It is an extremely light oil, somewhat lighter than water, and though it has been used extensively for creosoting railway sleepers, sufficient time has not yet elapsed to show whether its preservative qualities are as great as those of the heavier class of oil. It will be remembered by those who are interested in the subject that Mr. S. B. Boulton, in his paper on the antiseptic treatment of timber, contended that the light oils, though possibly rich in tar acids, were not as valuable as those which contained bodies which solidified within the pores of the timber. Mr. Boulton has recently advocated the creosoting of green timber by a slight alteration of the ordinary process. He avails himself of the difference in the boiling points of water and of creosote—water beginning to distil at  $212^{\circ}$  F., the required temperature for heavy creosote ranging from  $350^{\circ}$  F. to  $750^{\circ}$  F.—the creosote is introduced at a temperature somewhat in excess of  $212^{\circ}$ , and the moisture from the timber is said to be driven off in the form of vapour, which is drawn off by the air-pump.



The good fortune which enabled the Americans to "strike oil" was followed by what may, perhaps, be called the discovery that gas rising in large quantities from the oil wells can be carried in pipes to adjoining cities, and used for lighting and heating purposes.

The gas is both odourless and smokeless, and the Pittsburg manufacturers have been using it to a large extent in their rolling mills. It has already very largely decreased the consumption of coal in that city, and from its cheapness cannot fail to affect the cost of production of those articles in which Pittsburg now competes so strenuously with Sheffield.

Is it not a matter for serious reflection when we see a nation, as America, gaining such natural advantages for her manufactures which compete with ours? And when we see another competition in Belgium, whose people bear the cost of the railways through taxation, so that its iron and steel and other productions may be cheaply carried to foreign markets.

The advance made within the past five or six years in the speed at which our great ocean steamers are driven must have been noticed by all of us; but the means which have been at the command of shipbuilders to enable them to obtain that speed with economy have not been much dwelt upon. One of the greatest advances that has been made is the power of carrying a considerably increased pressure in the boilers without using excessively thick plates, by the introduction of steel for boilers, and lately by the use of the Fox corrugated flue, pressures of 160 to 170 lbs., which were before unheard of, being now common. The two-cylinder compound engine, which did so much for ocean steamers, is being displaced by the triple and quadruple expansion engines which have been made possible with these increased pressures. The latter type of engine owes much to Messrs. Denny, of Dumbarton, who have made it a commercial success.

The Fox corrugated flue to which I have referred has

required for its construction plant of a very special nature. The steel is made by the Siemens-Martin process, which is then rolled into large-sized plates. Having been bent into a circular form, the edges of the plate are heated by an explosive mixture of gas and air, which is passed through a Root's blower, and forced through special burners on to the plate. As soon as a length of about eighteen inches is at a welding heat a rapidly striking steam hammer closes up the edges, when the flue is moved back to the burner another length is heated and hammered up, and this process is repeated until the flue is welded from end to end. It is then taken to a large furnace, from whence, when at a bright red heat, it goes to the corrugating rolls, which turn out the flue completed in less than five minutes.

This process is at present only being used for the production of these special flues, but it appears to me likely that the power which it gives of producing thoroughly reliable welds will ultimately result in our being able to obtain boiler barrels finished complete without any necessity for joints or rivets. Barrels 8'-6" in length, and about 4 feet in diameter, could now readily be made. An important improvement of the same kind for marine work is about to be tried by a Barrow firm for rolling boiler rings without any weld up to diameters of 16 feet and in widths of 4 feet. In this case the circular seams of boiler will have to be riveted, but the great advantage of getting rid of the longitudinal seam is at once apparent. Special plant for the construction of these rings has already been made, and its working results should be of the greatest interest, not only because of the great improvement in the boilers themselves, but also because it will lead to a reduction of hand labour, and alterations in the way of machining the plates in the boiler shop. In fact, the use of either the welded or the weldless rings, to which I have referred, will make quite a change in boiler construction by

transferring much of the work now done by the boilermaker to the hands of the steel manufacturer.

When speaking of steamships I should not omit to mention that splendid specimen of marine engineering—the steamship “Ireland,” recently built for the Holyhead and Kingstown mail service—a vessel which upon the trial trip ran at a speed of 20·2 knots per hour, and which could, no doubt, exceed that speed now that she has been at work for some time. The engine and boilers do not call for any special remark, but the fact of the latter being worked under a forced draught is a novelty for steamers of her size. The indicated horsepower developed during the trial trip was 6,337.

One of the exhibits of the Antwerp Exhibition was a complete set of models showing the method of making wrought-iron wheels, according to the Arbel system, by hydraulic power, and an inspection of this machinery, as used in some of the wheel-making shops in England, is of the greatest interest. The ordinary railway wagon wheel, which used to be made of rolled spokes with a cast-iron boss, is now made with a wrought-iron boss pressed round the spokes by hydraulic power. The iron which is to form the boss is raised to a welding heat, the cold spokes having previously been placed in a special die under the press, and, when ready, the boss is dropped into its place in the die, and then pressed home, completely surrounding the spokes and making a solid and durable wheel, which may be bored out and pressed on to its axle without any fear of fracture.

I would like to direct attention to an extremely novel and ingenious model, exhibited by Professor Shaw at the Inventions Exhibition in London, for transmitting rotary motion to a shaft, and reversing that motion at will by means of a sphere, the axis of rotation of which is varied to produce the desired change in direction or variation in speed. It is quite possible that a modification of it may be of the greatest service for

varying the speed of all machines in which cone pulleys are now used, and for such machines as require alterations in speed without throwing the straps out of gear it will be very valuable. It is certainly one of the most ingenious inventions produced in that Exhibition.

Another invention which may also be seen there is the Maxim machine gun. This weapon is constructed so as that when once it has been started it automatically loads and fires the cartridges which are supplied to it on a belt, which it draws up from a receptacle below. The force of the recoil alone is utilised to perform all the operations required, and the attention of the man who has charge of the gun need only be given to seeing that his aim is correctly taken. So long as the gun is supplied with cartridges so long will it go on firing, at a speed which can be varied by an ingenious arrangement from one to 500 shots per minute. Should a cartridge hang fire it merely delays the action of the gun. It is very light and easily handled, and bids fair to play an important part in future warfare.

Electricity, which has done so much and with which we have expected to do so much more in various ways, has not as yet produced a storage battery which is at the same time economical and occupies but a small space. We have not as yet arrived at the time when anyone can, with reasonable economy, light his house with incandescent lamps at a price which will compare favourably with ordinary illuminants; and unless the ordinary householder is capable of understanding and attending to an engine and dynamo, he must yet wait before he can gain the undoubted advantage of the electric light at a reasonable cost. With large spaces and certain classes of buildings, the case is very different; and when the arc-light can, either with or without a certain proportion of incandescent lighting, be used to give large amounts of light, it is found to be economical as compared with its older rival, gas.

I would, however, point out that one direction in which even greater economy could be obtained seems to be in the production of cheaper but still reliable carbons. Unless carbons are of the best possible kind they flicker and give off a large quantity of dust which gets into and clogs up the mechanism of the lamps.

In order to illustrate how important is the question of the cost of carbons I may mention, that in a large installation with which I am familiar the carbons cost 40 per cent. of the whole expense of working; wages amount to 30 per cent.; coal to only 14 per cent.; the remaining 16 per cent. being made up of all the smaller items of repairs, oils, tallow, waste, leather belts, &c.

Those who have had anything to do with the erection of electric lighting plant cannot help being struck with the number of German workmen who are employed in connection with this work, and it is no doubt due to their possessing a greater knowledge of electricity and chemistry which our own workmen have not the same facilities for obtaining; and this fact is but one of many which may be brought forward to illustrate the necessity of the establishment of technical and scientific schools in our large towns. How little has been done in England and Ireland, and how much in Germany, to foster scientific and also technical education, was shown in the admirable address of Dr. Lyon Playfair to the British Association.

The difficulties which exist with regard to small installations of electric light for household purposes are almost the same as those which prevent its use for the lighting of railway trains.

Several experimental trains have been lit, and some of them are still running on the various lines in England, with incandescent lamps. In one system an engine and dynamo is fixed on the locomotive, but the light goes out if the locomotive is detached, unless there is a storage battery in the van. In



another the dynamo is driven from the axle of the van. In a third storage batteries are entirely depended on; but nothing that I am aware of has as yet been produced in a handy, and at the same time an economical, form which will enable any carriage to be detached from a train and carry its lights with it for a number of hours. What is required is something of the simplest possible character, easily attended to and not demanding of lampmen more intelligence than is now required to turn a gas tap.

In cases where oil-gas is used for train lighting the gas is produced by running the oil slowly into a red-hot retort. This gas has a very high illuminating power, and can be pumped into reservoirs under the coaches at a high pressure, the steadiness of its burning depending upon the excellence of the regulator, which reduces the pressure to the point required before the gas passes to the burner.

Lighting in every form has made great strides, and whether we look at the improvements made in the duplex lamp for burning petroleum, the regenerative gas burners of Siemens, or the Wenham or Clarke's or Bower lamps—all of which are vast improvements on what was being done before the electric light taught people to ask for a better light than they had hitherto received—we cannot help appreciating the value of competition in developing invention.

The introduction of steel sleepers on our railways is one of those modern improvements which is gradually coming forward. The success of both iron and steel sleepers has been so complete in other countries, where they have been in use in large quantities for lengthened periods, that it seems almost strange that their adoption here should have been so long delayed, and that we should have continued to import vast quantities of timber from the Baltic when we had within our own shores the means of making a better and more lasting article, and, further, of creating a demand at home for

materials at a time when foreign competition has made sad havoc with our steel manufacture.

The method of fastening the rail to the sleeper has formed the subject of numerous patents, but nearly all those which depend upon the use of bolts and nuts have been found to shake loose in time. A wrought-iron chair riveted to the sleeper seems to withstand the effects of vibration, and enables the rail to be held in position by means of the ordinary key.

There are also several forms of sleepers in which a portion of the sleeper itself is turned up to receive the rail, and thus to form a kind of chair into which a wedge can be driven.

On some of the Indian railways where iron sleepers are used, a wooden wedge has been driven under the rail with the idea of giving additional elasticity.

Another use to which channel and angle iron and steel sections will be largely put within a very short time is for the construction of railway carriage and wagon frames. They are already in use on some of the English lines and almost universally abroad. The Great Western Railway have used them for many years, during which they have gained such experience as to show that iron frames are much more durable than wooden ones, while the cost is about the same. In Belgium every carriage frame which one sees is made of wrought-iron or steel, and in Austria and Germany we find all the carriage panels made of thin iron plates.

The steady increase in the efficiency of machine tools is a matter which I think it desirable to mention. Large quantities of work which used to be done on planing and slotting machines are now dealt with on the more modern "milling" machine, which, in addition to the advantage of a continuous cutting action, can be driven so as to give a higher cutting speed per minute, saving at least one-third the time occupied by the older reciprocating tools.

Hydraulic power has worked a complete revolution in the methods of dealing with boilers and forgings. The excellence of the flanged portions of modern boilers could not have been attained without it, and forgings of every conceivable shape are now being made under the hydraulic press with the greatest perfection.

The great Sheffield firms have laid down some hydraulic presses of enormous dimensions, with a view of taking their steel ingots direct from the furnace, and reducing them at one powerful squeeze to the size required. It is not always safe to predict, but it seems probable that the use of the steam hammer for reducing very large masses of metal will soon be a thing of the past.

The application of hydraulic power to the cranes on board steamships, which have hitherto been fitted with steam winches, is an important improvement of recent date. Steam winches, working their engines at 1,000 ft. piston speed per minute, rarely lift at a greater rate than 2 ft. per second, while the hydraulic cranes placed on a vessel like the S S. Quetta work smoothly and noiselessly with an average lifting speed of 5 feet per second, the water being pumped into a steam accumulator up to a pressure of 800 lbs. per square inch by a pair of compound engines running at 60 revolutions per minute.

On board vessels of war hydraulic power is used in almost every conceivable way—for moving the guns, for carrying the shells up from below, and, finally, for placing them in position, and for actuating much of the vast quantity of machinery to be found on a modern ironclad.

We have long been familiar with the use of hydraulic power in connection with docks and railways both for lifting loads and shunting wagons; but the power of obtaining water at high pressure for working lifts or small motors, or even a considerable number of machine tools, at a rate per 1,000 gallons,

has not until lately been given to the public. Commencing at Hull, the Hydraulic Power Company were so successful that they laid down engines and plant in London, and obtained an Act of Parliament to bring their mains through the public streets and supply water to all consumers. The water used is pumped from the river Thames, and is measured by a meter at the exhaust side of the motor used in each case, and it then flows into the drains and back into the river from whence it came. The advantages of perfect silence in working, and absence of all heat and smell, without any risk whatever, must render the hydraulic power a serious competitor with the gas engine, which has become such a popular means of obtaining power for small machinery. The gas engine, which for many years remained a noisy, unsightly machine, received a sudden start when the Otto pattern was constructed by a well-known firm of mechanical engineers, who not only succeeded in making a thoroughly efficient and workable engine, but showed what careful design could do in producing a good-looking machine. Since the introduction of this engine numbers of others of very varied types have come into the market, and much has been written on the subject, but no more interesting paper has been read before the Institution of Civil Engineers in London than that of Mr. Dugald Clerk on the Theory of the Gas Engine. Mr. Denny Lane, of Cork, has also written more than one paper on the subject, which contain information of a useful character.

Gas engines are in some places driven by the gas made by the Dowson process, and all the engines in use at Messrs. Crossley's works in Manchester, are worked with it. It is said to be exceedingly cheap. A larger quantity of gas is required than is the case with ordinary coal gas.

A mistake is often made in supposing that gas of an inferior illuminating power will do as good work in a gas engine as a better quality, and it has been stated with some authority that

while an increase of 120 per cent. in the illuminating power of gas adds only 50 per cent. to its heating power, it adds considerably to its value for motive power. In one case, with gas of 12 candle power, 48·08 cubic feet per horse power per hour were required, while with gas of 29·14 candle power only 20·34 cubic feet were used. The economy to be gained is, however, entirely dependent on the price of the gas.

In concluding, I would remind you of those two great works, one of which is nearing completion—the Severn Tunnel—and the other the Forth Bridge, which is proceeding as rapidly as such an undertaking can be expected. The former, commenced as early as 1873, is now so far complete that a train has passed through it. The tunnel is  $4\frac{1}{2}$  miles long, the portion under the Severn being  $2\frac{1}{2}$  miles. It is said that the tunnel with its attendant works will cost about £2,000,000. The opening cannot be without influence upon the cross-channel trade with Ireland and direct communication with America.

The Forth Bridge crossing another waterway has called forth not only novelty in the design of the structure itself, but novelty in almost every machine used in its construction. Special tools for bending, drilling, planing, and riveting the plates have been designed to deal with each section of the work, many of which are due to the mechanical ability of Mr. Arrol, one of the contractors. No greater or better illustration can be found to show that in these days mechanical genius must be found hand in hand with scientific research if great results are to follow.

[2nd December, 1885.]

ROBERT MANNING, Past-President,  
in the Chair.

The Officers of the Institution were balloted for and duly elected (see List of Members).

The following Awards made by the Council were presented by the President, viz. :—A Mullins Silver Medal to JAMES PRICE, Member and Past Vice-President, for his paper, "The Shortest Route to India;" The Smith Premium to HENRY A. IVATT, Member, for his paper, "Breakdown Tackle for Railway Work."

The following Candidate was balloted for and duly elected, viz. :—

JOHN GRAHAM PURSER, as Associate.

#### COUNTY WORK IN IRELAND CONSIDERED IN RELATION TO GRAND JURY LAWS.

By HENRY V. WHITE, Member.

THE author is not aware that the subject of expenditure on public works in Ireland under grand juries has ever been before this Institution; and the matter being of national importance, in addition to being of interest to many members of this body, appears sufficient reason to bring it forward—and now in a special manner, in view of the certainty of great changes in their constitution due to the establishment of County Boards to replace Grand Juries, possessing comprehensive powers; and no doubt the members of this

Institution who possess knowledge on the subject will find it their interest and duty, in view of these changes, to forward to the Government, in due time, such practical recommendations and suggestions as experience suggests for the improvement of the existing system to the general advantage of the public; and to the County Surveyors specially it belongs to guide legislation usefully and practically in that direction.

Even were the changes indicated never to be carried out, the practice in different parts of Ireland varies so considerably that it is well to compare results, with the object of attaining uniformity where results are satisfactory, and of avoiding such customs that are proved by experience unsuitable or inefficient. And it is proposed by the author, after reviewing the subject generally, to make a few suggestions, not necessarily as being the best, but which, taken together with the facts to be laid down, may be of some use as preliminary to having the whole matter thoroughly investigated. It is, perhaps, impossible to consider the subject in all its bearings comprehensively without a full knowledge of every part of Ireland; nevertheless, this paper, imperfect as it is, gives the actual results of practical experience and close attention extending over eleven years.

For the information of those imperfectly acquainted with the system, it may be mentioned that the County Cess tax is levied for the following purposes:—Construction, repair, and maintenance of roads, bridges, harbours, court-houses, prisons, hospitals, industrial schools; also for inquests, Constabulary (part), expenses of general valuation (part), repayment of Government advances, expenses under Franchise and Registration Acts, malicious injuries—with some others of minor importance. The prison expenditure has been recently transferred to another Board, and probably many of the functions now discharged at central offices in Dublin, such as Public Works, Police, and Local Government departments, will be

transferred to the new County Boards, amplifying their powers and jurisdiction compared with Grand Juries.

The items of expenditure of more special interest to us are those relating to Public Works, such as roads, bridges, buildings, drainage, &c.; and it will be found, upon investigation, that over one-half of the gross annual amount of presentments in Ireland made by Grand Juries is expended thus—not including cost of supervision or repayment of Government advances made towards similar purposes, which may be taken at one-third more, or one-sixth of the whole. Hence, about two-thirds of the gross presentments made may fairly be taken to represent the total expense of carrying out and executing works of public utility in Ireland.

To illustrate these remarks the following table has been prepared. The author regrets being unable to furnish returns for the last two years. The table extends from 1879 to 1882 inclusive. The column Public Works represents all current expenditure on works of utility and maintenance, exclusive of salaries:—

*TABLE of Presentments and Expenditure made by Grand Juries of Counties, Cities, and Towns in Ireland in following years:—*

YEAR	Public Works	Government advances	All others	Gross amount of Presentments	Amount of Re-presentments and other Credits	Nett amount of cess levied
	£	£	£	£	£	£
1879 -	711,342	104,735	453,963	1,270,040	85,347	1,184,693
1880 -	651,750	229,619	342,640	1,224,009	76,563	1,147,446
1881 -	639,522	211,771	366,693	1,217,986	70,246	1,147,740
1882 -	645,883	141,649	489,001	1,276,033	80,072	1,195,961
Average -	661,999	171,943	413,074	1,247,107	78,057	1,168,960

Attention is directed to the column headed "Re-presentments and other Credits;" the meaning of this is, excluding



insignificant sums in aid which may be completely neglected, that from a current estimated public works expenditure averaging £661,999, a sum averaging £78,057 has not been used for the purpose intended, the work not being done, which money is refunded in each county towards the future rate, or about one-eighth of the entire amount presented for public works.

In dealing with the normal current mean annual expenditure (exclusive of repayment of advances from Government), it may conveniently be classified into roads and other works—the expenditure under the former head being very much greater—practically the relative rates are in a constant proportion, as the ratio of expenditure in each class varies scarcely perceptibly in any county from year to year.

From a valuable return made out by Mr. Richard A. Gray, of Dublin, in the year 1872, which does not appear, however, to include cities and towns, the proportion is found to be as follows:—

Road Contracts (maintenance)	-	-	£528,459
New Roads	-	-	26,313
Total	-	-	<hr/> £554,772

The cost of bridges and gulleys, &c., is put down at £56,958. There would appear a couple of trifling inaccuracies in the returns sent to Mr. Gray in the case of road contracts for Longford and Leitrim. In these counties the author believes the amount entered was only the half year's levy, and should have been doubled; he is certain of this in the former county. This would bring the total expenditure under roads from £554,772 to £562,255, which would give on the total expenditure for public works a preponderating ratio of more than 10 to 1 on roads, which may practically be taken as correct for each county in Ireland in all ordinary circumstances.

Such being the case, the author's observations will refer

principally to roads; and on success in their maintenance the efficiency of the entire system mostly depends. He does not consider, at all events, that the carrying out of any other public works by contract or otherwise presents any serious difficulty under existing laws.

It may be well to describe here briefly the main features of the Acts at present in force regulating Public Works.

The titles of those most in use are—

6 & 7 William IV., cap. 116, Amendment Act.

14 & 15 Victoria, cap. 92, Summary Jurisdiction Act.

19 & 20 Victoria, cap. 93, Amendment Act.

20 & 21 Victoria, cap. 15, Amendment Act.

These are the principal. There are several others, and there are numerous special Acts and Orders in Council relating to tramways, which for many reasons have not yet been availed of to any extent for the extension of tramways in Ireland.

Grand Juries, as at present constituted, are selected by each High Sheriff very much in the order he pleases, and they are for fiscal business non-representative taxing bodies. No doubt in theory this does not accord with modern democratic views; but speaking generally, and with very few exceptions, in practice they perform difficult duties remarkably well, and to the general satisfaction of the public. And there is reason to fear if the future elected Boards to replace them are taken from an inferior class, the results as regards carrying out of public business may be disastrous, unless due precautions are taken.

All applications for public works under these Acts must be brought in the first instance before the Presentment Sessions of the barony in which the work is situated. The Court consists of magistrates and associated ratepayers, who, after hearing evidence, approve or disapprove of each presentment in whole or in part. Those approved of are then advertised

to be done by contract. Specifications are written defining each work, and at the adjourned Presentment Sessions, held shortly afterwards, tenders are opened, the lowest being generally accepted, bail bonds being entered into as security that each work will be carried out as specified. These contracts, then endorsed by the chairman, who must be a magistrate, are forwarded to the next Grand Jury, who either ratify or disallow these contracts, after which these various presentments, approved of, are fiatd by the Judge of Assize and become law.

These Presentment Sessions are held twice a-year in each barony in Ireland, some time previous to the ensuing Spring and Summer Assizes for each county.

The contracts for repairing or making roads entered into at Sessions may be divided into two classes—specials, and works of maintenance. By specials are meant contracts to fulfil certain conditions by a certain date—thus (a) to make a new line of road; (b) to repair a road in bad order; (c) to widen, repair, and improve an old road. These are common forms of specials, the contractor being required only to have these works executed in a certain manner, and according to specification, on or before a given date. As a rule, these kind of contracts for roads or any other public work present comparatively little difficulty to those responsible for having them executed; but road specials involve only a trifling proportion of the entire average expenditure on roads—being about 5 per cent. only—the other item, maintenance expenditure, amounting to about 95 per cent. of the whole.

It has been shown that the mean annual expenditure for public works (exclusive of repayment of Government advances) may be estimated at £661,999. Deducting 10 per cent. for bridges, gulleys, and miscellaneous, and 5 per cent. of the balance for specials, we have a nett annual expenditure on maintenance road contracts of £566,085, or 86 per cent. of the

entire amount presented for current public works, exclusive of the expense of supervision, which, if proportionally added on, would further increase the preponderance. These details have been mentioned to illustrate the magnitude and importance of these maintenance road contracts, compared with all other public works put together, under ordinary average circumstances; and therefore, it is specially necessary, if opportunity occurs, to improve the existing laws with regard to them, if defective, and of adopting at present those modes of procedure in dealing with defaulting contractors that experience proves to be the most effectual. For it is to be remembered that the whole Grand Jury system is based on the assumption that roads are to be maintained by contract, the lowest tender being accepted in every case, unless there is some special reason to the contrary.

The essential feature of these contracts is, that the contractor and his sureties bind themselves, in a penal sum, double the amount of the contract, to supply materials annually as specified, and to keep the road for the term of years allowed at all times in perfect order, these contracts being for not less than one, or more than seven years (the legal limit)—the usual time allowed at Sessions is three years; and before proceeding further with regard to these bonds, a difficulty may here be mentioned as to an inconvenient and apparently irregular custom.

Now, the contractor, in the form of tender generally used, and which is found very suitable, enters his price at so much per perch per annum. And the Act states, referring to public works in general (6 & 7 William IV., cap. 116, sec. 22)—“The contractor and his sureties shall bind themselves, in a penal sum double the amount of the said sum mentioned in such tenders and proposals.” Now, the custom is for the amount of the bonds for roads to be made out double the tender per annum only; but strictly and regularly

it would appear evident that this annual sum should be multiplied by the number of years to run, and that the word "amount" in the Act refers to the payment demanded by the contractor for doing the whole work, and not portion only.

The following illustration may be given as an example, and is by no means an unusual case:—A bad contractor takes up a road at half the lowest price it would reasonably be expected to be done for under ordinary circumstances—at £50 instead of £100 per annum for three years. On the completion of the contract £300 would represent the total value of labour and materials the road should have received; but assuming he half does the work—which is the most that probably may be expected—after crediting him with this and realising (a most improbable case) the full amount of the bond, the county will still be £50 short of the sum that would be required to complete the work, taking the bond as made out for double the annual tender.

Next, for these maintenance contracts a very important matter, the conditions and modes of payment, may be considered; and the subject may be viewed from a legal or practical point. It appears to the author that the mistake was made when the Act was framed of confounding ordinary and maintenance contracts together, or very nearly so—there is little, if any, analogy. As to the legal aspect. Each contractor's pay is levied in two equal half-yearly instalments—in March and July—the money levied the previous Assizes being payable the Assizes following; but, speaking generally,  $\frac{5}{8}$ ths of the work is done between July and March, the remaining  $\frac{3}{8}$ th during the remainder of the year.

Now, the legal condition on which a contractor for any public work is entitled to payment is clearly laid down under the 130th section of the last-named Act in the following words:—"And be it enacted that every person who may contract for the execution of any work under this Act shall,

on the completion of the work for which he may have contracted, or whensoever by the terms of such contract he may be entitled to payment, give notice to the County Surveyor of the County ten days at the least before the day appointed for the holding of the first Presentment Sessions in the County after every Assizes or presenting term, of his intention to make application as hereinafter provided, and require of such Surveyor a certificate of the due execution of such work or performance of such contract."

Commenting on this section, the authors of the last edition of Foot make the following note, with which the author of this paper is inclined to agree, although it would be completely impossible to carry it out:—NOTE—It appears that the contractor cannot apply for payment at all until *after* the period provided by his contract.—*In re Bradley*. Now, should this note represent the strict law, a contractor might have to wait three or seven years, unless special provision was made otherwise.

However, let us proceed to consider this legal aspect as more commonly understood and applied. Each contractor makes his application to receive the half year's pay at Assizes the Presentment Sessions previous. And let us take for simplicity the case of a contract for one year commencing July Assizes and ending July Assizes following. Here the contractor, assuming he does his work between July and March, naturally then expects the half year's levy presented when the contract commenced, especially considering that  $\frac{2}{3}$ ths of the work will have been done ordinarily by March Assizes. This amount must be certified for by the County Surveyor at the November or December Sessions previous, payable the following March. Thus, he is obliged to certify beforehand that the work has been done up to March. This is unreasonable. The only thing he can do is to certify that the contract was performed up to date of Sessions, for half-year's levy, and get this

payment disallowed at Assizes if the road was neglected afterwards.

With regard to these half-yearly applications (called the long and short half-years respectively), the legal question arises—Can a portion only of a half-year's application be certified for, and allowed, or must each entire half-year's pay, as it stands, be either allowed or disallowed. The author does not pretend to decide this point—a most important one; but he has always been of opinion that this 130th section, taken together with the 42nd section of same Act, does give discretionary power; but, in the event of such not being the case, it is evident that no contract could safely be entered into commencing the short half-year, when one-sixth of the work only has to be done, unless special provision could be made to pay no money until the end of the year. However, if the legal power exists of certifying part-payment in a half-yearly application, it would be better to commence the contracts in March, bringing forward the proportional balance unpaid to the next half-year. This gives more time for preparation of materials, &c.

It may here be observed, with regard to the objection pointed out of certifying in advance, that this could be avoided altogether by granting no certificates for works executed up to Assizes until the Sessions following; but, practically, it would never suit to defer payments so long as this would involve.

The next point is to consider different modes of practice with regard to payment, in view of these difficulties.

In one district where the author endeavoured to introduce the principle of part-payment, as explained, it was considered not in accordance with the law, but, on being transferred elsewhere, he found that practice long established. And, as affecting its desirability or necessity, it is material to consider whether, in each particular district, the 128th section of the

6 & 7 William IV., Cap. 116, is in general operation, or not. This section provides for making advances to such contractors, not exceeding three-fourths the value of work done from time to time, where the "cost," in the words of the Act, of executing such work shall exceed £20. This "cost," in the absence of any clear definition, the author assumes, for a maintenance contract, to mean yearly pay. Now, in districts where this advance section is universally acted upon it might make comparatively little matter the necessity or otherwise of certifying for each whole half-year, or none. If the practice happened to be against part-payment being allowed at Sessions it could readily be arranged, by means of the advance section, to allow as much as was proper to allow, the balance being either re-presented in aid of the rates or brought forward with the future half-year's pay about to be presented, according to the requirements of each particular case. If, however the custom happens to be against part-payment, and that the section is not in operation, or, in other words, where the contracts are short in length, averaging a mile to two miles only, and under £20 per annum, it is very difficult to manage properly under these circumstances. And the following reasons may be given as to the desirability of discretionary powers being possessed for granting part-payment:—If the contractor is to get all, serious faults must be passed over, provided the work is generally got through in accordance with specification. This tends to develop an uncertain, irregular, slovenly mode of getting through work. If he is to get no payment under these conditions—not ten per cent. of them, at any time, would be entitled to be paid. The difficulty is great, and is clumsily attempted to be grappled with in some counties where the payment is all or none, by disallowing the half-year, and bringing the disallowed payment forward to the next half-year, as a bribe to the contractor that if he improves he will get both payments together next time in full—that is, payment for work not done in the past, on



condition of doing what he is bound to do in the future, with the alternative of having one or both of them struck off altogether in the event of further neglect. Sometimes even three maintenance payments may thus be seen "hanging on" the presentment book together. The principle is radically bad, but it must be adopted sometimes. The author often, at the end of a year's term of contract, where £50 say is the amount remaining to be disposed of, is well satisfied to allow £45, and think the applicant well punished for neglect, by striking the £5 off in aid of the rates.

In this important matter of payment the author commends the practice he found established in the Queen's County—it is as follows:—The contracts are generally for three years, commencing in Spring. And, taking for illustration the ordinary case of a road at £40 per annum—the first half-year's levy, £20, is collected between Spring and Summer. In hardly any case will more than from £5 to £8 worth of work be done in that time (four months). Taking it at £6, there will be a sum of £14 cash brought forward to the next half-year, which can be paid, under the 128th section (to which further reference will be made), at any time, to the contractor, after Summer Assizes. At the end of each year certificates are only granted, in each case, for the amount deemed proper, the balance going in aid of the rates. This supplies a cash fund sufficient generally to meet current expenses between Spring and Summer Assizes. Another very good practice may be remarked, which meets completely the difficulty referred to about certifying "in advance."

*All* payment applications are allowed in "full" at the Presentment Sessions, with printed endorsements thereon "approved," subject to county surveyor's certificate at Assizes, so that the author, *on* the dates of completion, and not before, is called upon to certify for payment in proportion to work done, or otherwise, as he may deem expedient.

Before this matter of payment to contractors is disposed of, there is an important branch of the subject relating to making advances under the 128th section. The author has given it special attention, and considers the practice good, provided due precautions are taken. Should they be made, however, indiscriminately for work partly done, according as applications come in, without any fixed principles in so doing known to the contractors, the tendency appears to be to encourage absolute paupers to take up unlimited work at impossible prices, relying on the necessity there is, once they become contractors, of being liberal with them to enable them to get along at all, not to speak of the endless contentions as to whether sufficient work has, or has not, been done to justify an advance in many cases.

As an appendix to this paper, the forms being too large to fit on ordinary pages, special sheets are printed, which explain the principles on which it is believed advances may judiciously be made. Appendix A has been devised by the author to meet difficulties, and gives satisfaction in use. Appendix B has been in use since the time of Mr. Horace Uniacke Townsend, his predecessor. It has been slightly altered only, and the margin headed contractor's statement has been added on. The "block" referred to in Appendix A is Appendix B, which form, with faults pointed out or underlined, is forwarded to contractor with a first advance. This block, thus marked, the contractor sends on, together with his application, when asking a second advance, and stating what he has done to remedy faults, &c. This is repeated a third or, perhaps, a fourth time in each year.

These observations bring nearly to a conclusion the subject of payment of contractors for maintenance road contracts. But it is to be borne in mind (a most important matter) that where cash payments have to be made before contracts are finished, or where periodical payments on account have to be made for

works in charge, carried out under county surveyor's supervision, provision must be made by Grand Juries to supply funds, as, in most districts, the moneys presented, say, in Summer Assizes for works to be commenced immediately, and gone on with up to the following Spring, are not collected and lodged until about that time. In Queen's County the arrangement is now such that, by judicious management, we can hardly ever run short. And a Special Order was obtained, July Assizes, 1885, to meet the difficulty for the long half-year; it was to the effect that a certain proportion of levy for each barony shall be lodged with Treasurer at least three months after each Assizes.

Having briefly touched on some of the more important matters bearing on Finance, two other important subjects remain for consideration—Maintenance Contracts and Contractors, and Works in Charge of County Surveyors. With regard to the former, the great difficulty is to know how to deal with defaulters. And before proceeding further, as may partly be deduced from previous observations, it may be stated that experience proves the great advantage derived in practice from consolidating small contracts together, so as to make them reasonably large, thus diminishing the number of contractors in each barony to be dealt with, and reducing the annoyances and difficulties to be overcome almost in proportion to the number of contractors. These contracts should average three to four miles in length, at least, and in the case of minor branches, or groups of branches adjacent to the main roads, it is often well to tack them on to the latter, the different branches and materials, &c., necessary for each being clearly set forth in a schedule attached to the specification.

It must in this be remembered that it is quite as easy, if not more so, to deal with comparatively large contractors as with those for small amounts—besides the advantage there is in being able to avail of the 128th section, in making advances

in many cases. Many of the most troublesome men to manage have contracts for very small amounts—this consolidation in the Queen's County was carried out many years ago by Mr. Townsend—whose many ingenious arrangements the author feels bound to acknowledge.

The primitive notion of having small or short contracts, appears to have arisen from the idea that the contract system would be found to work fairly well, that cases of neglect could be readily dealt with, and to give opportunities to small farmers and others, who could not afford to carry out large undertakings, of competing for them. Unfortunately, however, experience has shown that, although there will be competition enough generally, it is not easy to get the work done properly. At the same time, contrary perhaps to what might be anticipated, the author finds the class of men who tender for the larger and heavier contracts now existing, is by no means what could be desired—they are often broken-down farmers with little or no means to enable them to carry on their work satisfactorily.

Before proceeding to detail the difficulties to be encountered, the author can only hope that the regulations recently made and explained with regard to making advances, will in future deter utterly incapable men from coming forward. There is, however, at present, no competition for these contracts, and in numerous cases no tenders at all are received consequently this has increased the number of roads in the author's own hands, as compared with those in charge of his predecessors up to 1883.

The following extract, though rather long, is given from a report to Grand Jury, Summer Assizes, 1884, and was written about ten months after his receiving charge of the district. Further experience confirms its general accuracy. It was dated 30th June, 1884:—

“With reference to the public works of this county, I have

the honour to submit the following Report, and in so doing deem it my duty to make some observations on the main characteristics of the system here in use, which I have carefully been considering for some time. It may be considered under two heads as regards its practical working—namely, contracts and works in charge—and in referring to these I only allude to the ordinary maintenance presentments for roads, the expenditure on which probably amounts to 95 per cent. of the entire outlay in connexion with this department. Now the great object to be attained is to have these works executed in the best manner at the lowest possible expenditure; and the first Grand Jury Act was based on the assumption that these results would be achieved by leaving them open to public competition, but after twenty-three years experience the Government found it necessary to pass the Act of 1857, which was intended to remedy, in the words of the preamble, the great loss and inconvenience arising from the want of ‘proper contractors,’ and we cannot but be struck with the fact, in coming here, of the large use that has been made of this Act compared with elsewhere, and the special development of a system calculated to render the Act efficient as applied to works of maintenance done by the Grand Jury.

“I may state, as the result of my own experience of nine years under a purely contract system, that, on the whole, it worked very fairly and economically in districts where the roads were firm, materials abundant, and the traffic was light. But where the traffic was heavy, and the roads were soft, it was very hard to get good contractors, even in cases where the tenders accepted were very much more than enough for the work. This arises from the fact that it is impossible to *prevent* neglect over and over again occurring; having it remedied afterwards is a different thing, and not satisfactory by any means. Such, however, is the state of the law, that this fact cannot be properly met under a contract system pure

and simple. Now, it is clearly evident, theoretically, that maintenance works ought to be able to be done cheaper by contract than doing them ourselves; the contractor is at no expense for supervision, he is generally assumed to be a man of some means, having a horse or horses of his own, and to possess a certain amount of free labour—all of which expenses come out of the presentment when done by the county. It is the practice here to limit the prices allowed to the amount sufficient to very fairly remunerate any person possessing these qualifications, and to do the work properly. In the Queen's County the objection to accept the lowest tender, when appreciably under the limit, is specially strong, in consequence of the "low limit" practice referred to. Elsewhere, Longford, for instance, the competition price is practically unlimited—it being allowed to arrange itself, unless in special cases. This ensured contractor's always, but the practice was necessary, as there could be no organised system for works in charge, for want of funds in hands. The practice here is better under the circumstances, as the ratepayers are certain of never having to pay more than the fair value. Unfortunately, even in the case of contractors who possess all the qualifications referred to, and take up the works at the full price allowed, they are not seldom dissatisfied with legitimate profit, but try to evade their responsibilities. Such cases can readily be dealt with here. I can get them done later on; but with regard to similar cases in which the contract price is considerably under the estimate, I will refer to these subsequently.

"It may perhaps be expected, with regard to county works in charge, having regard to the extra cost incurred, not all generally borne by contractors, horses, payment (poundage), labour supervision, &c., that we cannot, therefore, fully do them ourselves at the full price, considering the nature of the limit allowed. To a certain extent this must be admitted, but we approach as near to it as possible; and, notwithstanding these

difficulties, or rather balancing them against the contractor's legitimate profit, *plus* neglect, the work done being more regular, I have no doubt that, after a couple of years steady attention it becomes easier, if not then allowed to deteriorate. The matter may also be put thus:—£50 presented to the county is expended, as far as can be, to the advantage of the county; £50 presented to a contractor for the same purpose is endeavoured to be applied, so that the maximum profit may accrue, and consequently the minimum of labour has to be done. Other things might be mentioned, but I have specially to note the advantage it is having immediate funds available for doing work as in this county, to which I have not been accustomed.

“With regard to road contractors generally, I wish to repeat what I said last Assizes, that in many cases they appear to possess little or no means of their own, and to take up the long heavy contracts in the most reckless manner, often without the slightest apparent intention of carrying them out. I anticipate soon having to get rid of many of them. The roads generally are in fair order, the weather having been fine, and those in charge are in a satisfactory state.

“It is necessary something should be done to defaulting contractors, especially those who take up work much under the limit. I must ask the Grand Jury to make an order, authorising me in future to proceed as may be necessary against such defaulters and their sureties, to recover damages for loss sustained, &c., before the County Court Judge, and have amounts decreed levied forthwith, and lodged to credit of presentments.

“The necessity of obtaining some such order is evident when the contract is under the price allowed, as the amount presented is usually insufficient to have the work done.”

It is necessary to apologise for the length of this “extract,”

but as it will, to a great extent, illustrate the application, not only of previous remarks, but of others about to be made, it was considered desirable not to curtail it.

Whenever, owing to excessive competition, or the expectancy of competition, a contractor takes up a road considerably under the price it could ordinarily be done for, this represents the most usual and hardest case to be dealt with. In fact, when this price goes well below a reasonable limit, it may be laid down beforehand that the work will not be properly done, and the public will have to submit to inconvenience in consequence.

Now, the first thing to understand well is, before going into the matter at all, the meaning of the term, "fulfilment of contract." The general run is for three years. The meaning is, that for these three years the road shall *always* be kept in good order, and a definite quantity (at least) of materials put on annually. It is more convenient, however, in practice to consider a contract for a term of years an annual one, renewed successively each year, until the term is out. The cycle of work (varying with the seasons) thus repeats itself each year, and is a constant quantity. Moreover, considering it thus, the possibility of the contract being broken 900 times in the three years, is minimised to 300 times; further, to illustrate the necessity of the limitation, if we consider that, according to the strict legal view, the contract is not completed until the end of the three years, consequently the contractor would have no right to receive any payment till after the full period had expired. Nor even then would he have any title to receive any payment whatever, unless *at all times*, during the three years, the road had been kept in accordance with specification.

There is no need to dwell on the impracticability there would be in carrying out this idea. On the other hand, it would never do to consider these contracts as extending only from



Assize to Assize universally for purpose of payment owing to to the relative inequalities of work to be done between times. For these and other reasons, which may be inferred from previous observations with regard to payment, having duly considered the matter with due regard to legal and other difficulties, the author has recently inserted the following clause into the ordinary form of specification:—

*Conditions of Payment for Work when done.*—This contract being for a year, or term of years, it shall be considered for purposes of payment for work when done, to have been “completed” at the end of each year, provided that all conditions herein contained are fully complied with *at all times* within the time to the satisfaction of the County Surveyor, and the contractor shall then be entitled to receive payment, on making due application after completion, but shall have no legal claim to receive money “on account” before this period has expired. And in the event of this road or contract being found at any time or times (within the term) in bad order, or work to be done grossly neglected, or contrary to specification, the County Surveyor declines to guarantee any payment whatever for labour performed, or materials put out previously during the year, and the contractor then forfeits all claim. Likewise, even should this neglect, or series of neglects, be afterwards remedied, it must be clearly understood that the contractor has essentially failed in the material condition of keeping “at all times” the work in proper repair during the yearly term; and, accordingly, the condition of the bond having been broken, the contractor shall have no legal claim to expect the County Surveyor to certify for “any payment” whatever.

With regard to this clause, making the contracts yearly, for purposes of payment, it becomes necessary in counties where they commence the light half year, much more than in counties where the contracts commence in July—there it might not be necessary at all, perhaps in most cases,

to adopt this arrangement. But to resume: there is an evident and particular necessity to be able to compel constant and diligent attention on these roads with regard to labour. It will not do to have them occasionally, during each term or year, put into perfect order, then to let them deteriorate and become bad : then again, after some time, put them into very good repair. All but the very worst contractors will do this much, and generally imagine by so doing they fulfil their contracts. If this principle be admitted for 364 days in the year, a road may be impassable, and next day, by employing a number of men and putting it in perfect order, the contract has been fulfilled. It is in the failure of being able to enforce this constant, steady attention so very necessary, that the difficulty lies, and this particularly during the winter months.

Now, the work to be done in each year may be divided into two parts—Labour and Materials; and in general, if a proper estimate is made of the cost on ordinary roads, about half the annual sum should be spent on materials, and the other half on labour. As to the materials, it is comparatively easy to insist on a supply approximating that specified being given, although hard enough often to succeed; but this difficulty is nothing compared with that experienced in getting the manual labour sufficiently done, or done often enough. With these preliminary observations, we may now proceed to consider the legal provisions existing for dealing with defaulters. They are four in number.

1st. The applications for payment may be disallowed.

2nd. County Surveyors have power of taking the contracts up under the 54th section of the Act, 6 & 7 William IV., cap. 116, and having the work done on serving the contractor with ten days' notice.

3rd. Proceedings may be instituted at Petty Sessions against the contractor and his sureties under the 19 & 20 Vic., cap. 63, sec. 17.

4th. The contractor and his sureties may be sued by order of the Grand Jury for breach of contract at Quarter Sessions, under the 117th & 168th sections of the Act, 6 & 7 William IV., cap 116; also the 6th section of the Act, 16 & 17 Vic., cap. 136.

Let these be considered in the order given.

With regard to the first, attention may be again directed to previous observations with regard to payment; also as to the legality of making part-payments for works imperfectly or incompletely fulfilled. And assuming that this can be done, it meets the emergency to some extent, and is, perhaps, all things considered, the only thing that can be done to a number of defaulters who get through the work from time to time, but in a slovenly, dilatory manner, sometimes giving a good, often a bad, road between each assize term.

*Second and Third Methods.*—The following is the text from the section of the Act first referred to, namely, the 54th section of the 6 & 7 William IV., cap. 116. It is so important that it will be given in full:—

“Provided always, that in case it shall appear to the County Surveyor, at any time during the continuance of any contract now made, or hereinafter to be made, for keeping any road in repair, that such road is not in proper repair, he shall require the contractor to put the same in repair; and if such contractor shall neglect to do so within ten days after he shall have been so required, such surveyor shall cause the same to be repaired, and the expense thereof shall be deducted and paid out of the sum which would be payable to such contractor if the road had been kept in proper repair.”

The following is the text of the other Act referred to, namely, the 17th section of the 19 & 20 Vic., cap. 63:—

“If in the opinion of the County Surveyor the contractor for the repair of any road shall be guilty of neglect or inattention in the performance of his contract, it shall be lawful

for such Surveyor to summon the said contractor and his sureties before the Justices at Petty Sessions of the district in which such work may be situate; and if such charge of neglect or inattention be established before such Justices, it shall be lawful for them to make an order directing the said contractor and his sureties to execute his contract within a period to be stated in such order; and if, at the expiration of such order, the County Surveyor shall still see reason for being dissatisfied with the manner in which such work has been executed, it shall be lawful for him again to summon the contractor and his sureties before the Justices at Petty Sessions, and the Justices thereupon shall proceed to inquire into and finally adjudicate upon the complaint; and if it shall appear that such work has been insufficiently executed, or contrary to the terms of the contract, it shall be lawful for such Justices, having ascertained the amount which it may require for the completion of such work according to the contract, to authorise such Surveyor to complete the same, and to levy such amount by warrant of distress, upon the goods of such contractor or his sureties, not exceeding the amount of the recognizance or bond of such sureties."

In reading over together and comparing these sections of different Acts of Parliament, it would appear at first that the proposed remedy is so clear and satisfactory, under either section, that the only difficulty would be to choose between them; there are, however, some very nice legal points involved, besides difficulties of a practical nature to be overcome. The first legal difficulty often raised is—Has the County Surveyor discretionary power of selection, it being alleged that the former section is only intended to apply to the case of a road contract for *keeping* any road in repair, while the later section is intended to meet the case of contractor's neglect for *the repair* of any road—in fact, to meet the case with regard to a road contract, of the nature of a "special," as defined in an

early portion of this paper, the law point involved has never been judicially settled; but as it is pretty generally held, the latter section is intended to be universal, it will therefore be assumed for simplicity that selection is discretionary; it may, however, be pointed out, in this case, that the section of the old Act is *mandatory* on the County Surveyor under the circumstances, while under the new Act it merely says "it shall be lawful" to adopt the procedure given; and the author, after considerable experience of both, is reluctantly compelled to come to the conclusion that whatever the value of the later section may be as applied to a "special," it is almost worthless for the purpose intended as applied to "maintenance" contracts, unless possibly in some very exceptional instance; he has, therefore, completely given up taking advantage of it. The first objection, and a strong one, to begin with is this, that assuming it works perfectly, as far as it is intended, it evidently was not framed to meet and *prevent* the state of affairs arising towards which the first remedy given (disallowing payment) may be said to be a partial cure; the latter, indeed, no more than amounts to this, for disallowing payment cannot prevent neglect occurring systematically and periodically, neither can this section—in fact, this objectionable section appears to assume it to be "unnecessary" for the contractor to do more than repair his road when required, and that he may break his contract by permitting it to become bad with impunity and as often as he pleases, provided he remedies this afterwards.

There is in practice one case in which County Surveyors have no option but to use it—namely, when county roads of importance are permitted to become bad or impassable, and that there are no funds in the hands of the County Treasurer (under circumstances explained in the finance part of this paper) to pay the workmen employed to do the work under the old section, for in such cases, otherwise, there would be no resource but to let them remain as they are until a prosecution

could be ordered by the Grand Jury at the following assizes to recover damages.

The following objections may also be made to the new section:—

1st. It is necessary to lose two entire days for one road generally, and most usually at the busy time of the year, before a decree can be obtained, appearing either personally or by solicitor.

2nd. In cases where two magistrates seldom or never attend, or where the Court only sits once a fortnight or once a month, it is easy to conceive its unsuitability to meet an emergency requiring prompt and immediate action.

3rd. The section does not state who is to levy the warrant; police usually have done so, but sometimes decline.

4th. In nine cases out of ten no assets are obtainable, whatever chance there might be in proceedings instituted before Quarter Sessions.

5th. Assuming a sufficient sum is realised to *put* the road in repair, and that it is a contract for a term of years, most probably in another fortnight or less it will be as bad again, and nothing can be done. A decree can only once be obtained on the original bond.

It comes, then, to this, that the only effectual method of dealing with the worst class of defaulters is under the old section, and there appears no way of compelling any contractors to carry out their specifications fully.

In practice under the old section, when roads are thus taken up, they should then be given in charge to overseers, or the assistants who arrange to procure materials, and employ horses, men, &c., sending in pay-sheets as may be necessary from time to time, if, in fact, the presentments become relegated to the class of works "In charge" to be treated of subsequently, but as will be inferred from the extract given of report to Grand Jury for Summer, 1884, there is a difficulty when the

contractor's price is too low, and then the only money available is insufficient to carry on the work; this cannot, however, be helped, the only thing to do is to exercise the greatest economy following up this proceeding by the fourth method mentioned for dealing with defaulters—namely, prosecution of the contractor and his sureties on the bond for breach of contract, and loss or damage sustained. These prosecutions at Quarter Sessions must be instituted by order of the Grand Jury; but to avoid the inevitable delay and inconvenience sometimes in getting these special orders made out each assizes, this Grand Jury, in Summer Assizes, 1884, issued a general order authorising their County Surveyor to take, from time to time, any proceedings he deemed necessary against defaulters in the future.

In this ordinary instance, when the contractor's price is too low, as no more can be expended, it is evident that he and his sureties should be held responsible for all loss, damage, or public inconvenience sustained in consequence; and with regard to this vital matter it is essential to understand the legal requirements in order that they should be held thus liable.

Now, it has been held that the onus of proof of the performance of the condition of the recognizance lies with the contractor; also held that the sum mentioned in the recognizance was not in the nature of liquidated damages, and that (the breach alleged being the non-erection of a bridge) to sustain the plaintiff's case some evidence of the damage actually sustained was requisite (per twelve judges—Attorney-General app., Wilson resp.); and in Foot's "Grand Jury Laws," also, the case of Attorney-General *v.* Moore is quoted as applicable to road contracts as follows:—

"But it is unnecessary to prove actual pecuniary loss, and evidence by the County Surveyor of the impassable state of a road in consequence of the non-performance of his contract by the defendant will warrant a decree for substantial damages."

When, however, it comes to the actual point of prosecuting a road contractor under the 168th section specially, in the event of a defence being entered, no matter how bad the contractor's case is, a sufficient decree will seldom be obtained; and before giving the established practice here, a few remarks will not be inappropriate as to the legal limit.

Now, there is considerable difference of opinion with regard to the sum mentioned in the recognizance. Some maintain that the mere fact of breach of contract at any time, or in any particular, will warrant a decree for the full sum; others as strongly maintain that actual money loss sustained (a practical impossibility in one sense) should be proved, and that for this loss alone the contractor is responsible. It does not appear there is any settled ruling in the matter; however, taking the latter view, it is easy to show that in many cases the amount theoretically capable of being realised is inadequate.

Assume the following illustration:—A undertakes to maintain a road contract for three years at the rate of £25 per annum, the proper estimate being £50 per annum, and he enters into a bond accordingly for £50 (here attention is again directed to former remarks as to amount mentioned in bond).

In ten or twelve months afterwards, the road having become impassable, it has to be taken up, and the work endeavoured to be carried out; but it is found that now it would take £75 to put it in proper repair, of which only £25 is available, and we will assume that, on prosecution, the contractor and his sureties will be decreed for the difference—namely, £50.

This being so the contract is legally at an end; but there are often difficulties connected with entering into a new contract before the old has expired, hence the £25 per annum only continues to be levied, and is the full sum available till the end of the three years.

It is evident that, to meet the case, adding on future cost, the decree should be, not for £50, but for £100. And,



moreover, in this illustration it has been assumed that "money loss" has to be legally proved—that is money actually lost—which is taken in different senses by different judges. The question may be asked—Where did the money come from, and where did it go to, that is said to be lost?

Having briefly reviewed the state of the law, the author will now give some experiences of these prosecutions.

In a former district one County Court Judge always gave decrees for the full amount of the bond, on breach of contract being proved. Another, his successor, gave decrees for amount that would be necessary to put the work in repair—what may be called a "proportional" decree.

In this district the late County Court Judge, also the present, acts on the same principle. In some counties it is usual to give decrees for the full amount, discretion being used in raising only as much as will be required.

A very important, recent decision was given here on appeal, the history of which may be mentioned; and that the points involved could be now raised at all is remarkable, considering how long the Act has been in force.

On Mr. Clarke's retirement, Mr, Monaghan, Q.C., was temporarily appointed County Court Judge, and prosecutions on the recognizances were instituted before him in several instances, but were all dismissed without prejudice, on the grounds that actual money loss—that is money "lost"—was not proved.

The author selected one of these to appeal, but this not having been lodged in time for next Assizes proceedings had to be commenced all over again before Mr. De Moleyns, the present County Judge. The same defence was pleaded, but Mr. De Moleyns, a very experienced judge, gave a substantial decree. The contractor on this appealed before Mr. Justice Murphy, Maryborough Summer Assizes, 1885 (*Attorney-General v. Delaney and others*), and the appeal was dismissed

with costs. And it has been thus established that contractors whose prices are too low, and who neglect their works, are liable for any cost it would take to carry them out.

The next branch of the subject may now be dealt with—that of “Works in Charge of County Surveyors.” These remarks, as hitherto, are meant principally to apply to “maintenance road contracts,” given to them to get executed under the Act of 1857, mentioned in extract from report. These include all necessary presentments for which no tenders have been received, or unsuitable tenders, also contracts taken up under the 54th section. Enough has been said with regard to the latter; but with regard to the former class, of course, they are taken up at the estimated price allowed at Sessions; and in these cases, unless there is no option, it is not desirable that they should be set by contract. Men should be employed,\* at the ordinary rate of wages, for the purpose of performing the labour necessary, also horses by the day. Materials may be provided by contract; and, of course, it is necessary to have overseers in each district to see after the men, &c., when the works are at all extensive. In some counties the district surveyors are given this extra work, with special allowance; but, generally speaking, it is better, perhaps, to engage disinterested men for this purpose. Pay-sheets for each presentment being sent in as often as required, which, when certified by the County Surveyor, are forwarded to the County Treasurer, who sends round a pay-clerk regularly to pay the men in each locality where they are working. Each man's time, work done, and amount due is marked in the pay-sheet, checked by the overseer, and payment is acknowledged by each person, to whom money is payable, affixing his mark or name in a column

\* The author believes that Mr. John Hill, County Surveyor of Clare, and formerly of the King's County, was the first to devise a comprehensive working scheme, for carrying out on a large scale “works in charge” when in the King's County; his success was remarkable.

for the purpose. The total cost of this supervision and payment of men amounts, at present in the Queen's County, to about 14 per cent. of the total presentments for works in charge; but the efficiency of the system, notwithstanding this cost, comparing the work done with that of contractors, is so evident and universally admitted as to demand attention. The only thing is the necessity of having reliable men as overseers, and, where extensively in use, the pay-sheets are troublesome to check over. It is, in many respects, a reproduction of the French system, to which reference will be made. And, as a general rule, the author finds, in the case of roads taken up for three years, if they have previously been in the hands of contractors they are often gone down in condition. And the ordinary price allowed does not admit of appreciable improvement for some time, perhaps for one, or, in bad cases, probably, not for two years. The author believes there are more roads thus in charge at present (August, 1885) in the Queen's County than there are in any other county in Ireland. The proportion is one-third of the entire, and the expenditure approaches £5,000 per annum. There are five overseers carrying out these works. Now, the great advantage this system possesses is, that the constant manual labour and steady attention necessary for good roads is certain of being given. And, not to speak of the contract system failing in Ireland in this respect, the author can state, from his own recollection of fifteen years ago, when associated with an eminent engineer then superintending the roads and public works for an important corporation near London, that this corporation, after experience of contractors, gave up employing them for ordinary works of maintenance and roads, and found it cheaper and far better to carry out these works themselves, with their own staff of foremen, artificers, and workmen.

A few remarks on this point may not be out of place as to the maintenance system adopted in France, suggested by the

little essay written some years ago by the late (then General) Sir John Burgoyne, Bart., when stationed in Ireland. He alludes specially to the construction and maintenance of the great roads under the charge of a public department—the Ponts et Chaussées, and to the district of the Département de la Sarthe, in charge of Mons. Dumas. A great change was instituted in the year 1837—namely, to devote out of the amounts allowed for maintenance of these roads increased expenditure and attention to constant repairs compared with proportional outlay on materials. Hitherto the results have been very satisfactory. One illustration will suffice—that of the road from Tours to Caen. In the year 1837 this road cost £1,088; £584 of this went towards materials, and £504 for labour. Between the years 1837 and 1841 the expenditure gradually diminished to £608, of which £163 only went towards materials, and £445 went towards labour. This road was in a dreadful state in 1836, notwithstanding enormous annual previous expenditure on materials. In August, 1838, it was reported very good, and since then has become better and better.

Now, in considering these facts, it is to be remembered that the provisions made in England and France for securing constant attention and manual labour, on the appearance of any necessity for same, do not exist here.

And with reference to the particular case quoted as to the saving made, and gradual proportional readjustment of expenditure between labour and materials, although it is not maintained owing to the difference of climate, traffic, and other causes, the same results here in proportion would be achieved. Nevertheless, much could be accomplished in that direction did proper means exist to enforce the due apportionment of work between labour and materials.

It now only remains to make concluding observations, then a few simple suggestions that it is believed, if carried out,

would remove existing difficulties, and would contribute to the comfort and convenience not only of the general public, but specially of those entrusted with the execution of these works—besides, on grounds of economy alone, the change would tend to diminish public expenditure.

In the present state of the law the results attained generally are by no means so extremely bad in the execution of public works by contractors, as might be anticipated from previous statements. Occasionally, indeed, in maintenance contracts the work done is at times very creditable. Much depends upon the men, and very much indeed upon the seasons, but unfortunately there is no guarantee or security that they will always be kept in the same satisfactory state; and it has been shown that about one-eighth (a pretty constant quantity) of the entire amount presented is annually refunded for work not being done. Now, the ratepayers have a right to expect, when these presentments are granted by them, that the works shall all be fully and completely carried out, that the money is to be expended and not put in aid of the rates, and this fraction, the measure mostly of local discontent, is altogether higher than it ought to be. It is due principally to defective, imperfect, or total non-fulfilment of maintenance road contracts. No doubt occasionally the adjourned Sessions Courts are not particular enough in selecting suitable men, but they really appear on the whole to do the best they can, and the matter of suitable tenders is still further complicated by a recent decision on appeal, from which it would appear that the lowest must be accepted if the security appears adequate. And now, having regard to all the facts brought forward, the following suggestions for amendment of the laws where found practically defective are made, on the assumption, of course, that there will be no radical changes introduced under the proposed County Boards as to the modes of procedure or machinery for carrying out public works. And it is also

assumed that the old laws which have lasted so long will substantially remain unchanged, whatever extra powers the new bodies may be vested with, or whatever changes may be made in their constitution. And here it is most necessary for the author to state, that he believes, with the exceptional clauses objected to, regulating conditions of payment and maintenance of public roads, these laws, taken as a whole, work extremely well, and are very suitable for all purposes intended. The more recent Acts intended for the promotion and development of the light railway or tramway system in Ireland have not yet come into general operation, and probably, though carefully framed, will require amendment to make them practical. Some small details as to the working of other clauses of the Grand Jury Acts, which might be improved on, have not been gone into. The subject is too large, and the defects are comparatively too unimportant to be mentioned at present:—

*First.*—It is suggested that a slight alteration be made to the 130th section of the 6 & 7 William IV., cap. 116, to the following effect:—That all contractors' applications for payment at Presentment Sessions shall be "allowed" or "disallowed" subject to the County Surveyor's certificate at Assizes, which certificate, if work is not fully completed, as specified, he shall be entitled to refuse altogether, but he shall have discretionary power to certify if circumstances render it expedient for payment in part only.

*Second.*—It is suggested, with regard to prosecuting maintenance contractors before the local or superior courts, to have the amount of damages for which defaulters are liable clearly laid down, as *at least* equal to any sum it would take to fulfil the contract for unexpired term, otherwise for the full amount of the bond.

*Third.*—It is suggested, with regard to maintenance road presentments granted for one year or a term of years, that the

20th section of the 6th & 7th William IV., cap. 116, be altered or added to, so as to enable the condition to be fulfilled of substituting what may be termed a "half contract system," instead of the present, as follows:—

The Presentment Sessions to have power to present to the county treasurer, after hearing evidence as to the amount required, a certain fixed annual sum towards each road presentment, to be expended thereon. The supplying of materials to be done by contract, according to specification determining quantity required, with conditions, &c., tenders for the same being received in the usual way at Adjourned Sessions, and contracts entered into for ratification by Grand Jury or County Board, the balance of the money so presented being expended in actual labour, &c., on each road by the county surveyor, under 20 & 21 Vict., cap. 15.

*Fourth.*—It is suggested that the 54th section of the Act 6 & 7 William IV., cap. 116, dealing with defaulting road contractors, after service of ten days' notice, be made applicable to the proposed contractors for materials.

Now, with regard to these, the first two require no explanation, the third and fourth may be taken together, and are, in the opinion of the author, by far the most important. In the first place, judging from experience, this arrangement will in future still admit of half the work being done by contract, and of a more healthy competition in this than there can be when labour is included. It is assumed that, out of these presentments, overseers' wages, pay-clerks' fees, tools, and implements, &c., will be deducted from actual expenditure. These charges, if the alternative suggested was carried out universally in each county, would never exceed 8 to 10 per cent. of the presentments, and the work would be executed, beyond all comparison, better and more regularly than can be at present. Of course the ordinary assistants in each county would continue, as now, to report on these contractors, roads,

and men, and generally see that county surveyor's instructions are carried out.

Next, the author has no doubt whatever that, if this "half contract" maintenance system for roads was brought into general use for one year, the expenditure might afterwards be reduced 10 per cent. on the usual price allowed for maintenance contracts at road Sessions, thus creating a saving in estimated expenditure in addition to superior work. Of course there would be no such thing under the proposed arrangement as re-presentments in aid for work not done, unless under special circumstances.

One point remains to be mentioned—the county secretary's, treasurer's, and officials' extra work to be gone through. The county surveyors, in particular, will be responsible for the carrying out of the presentments, and for the expenditure under overseers appointed by them; they will have also the regular checking of accounts and numerous pay-sheets. The overseers should enter into bonds for the proper discharge of their functions. The work on the pay-sheets (applying to treasurers and secretaries also) for roads may be illustrated thus:—

Assume a county with ten baronies, and 100 miles of roads in each barony, the expenditure annually on these 100 miles being estimated at £15,000. Of this amount, £7,500 would be discharged in the ordinary way out of funds presented to contractors for materials. For convenience, it is suggested that the entire sum allowed for each presentment might be presented to county treasurers direct, and there now only remains £7,500 to be disposed of in pay-sheets.

Now, to prevent these being sent in in overwhelming numbers at a time to the office, the following arrangement could easily be carried out:—Each overseer should forward his pay-sheets once a fortnight only, and, to divide the work, the various district accounts should come in alternate weeks; and generally speaking, an average of twenty pay sheets, repre-



senting repairs done, may be assumed for each road in a year ; and, assuming each road four miles long, this would give 250 presentments altogether, and  $250 \times 20 = 5,000$  annual pay sheets, or an average of nearly 100 per week. In winter, no doubt, this number would be higher, and in summer the proportion would be less.

As already mentioned, there would be constant work for county officers, and the material interests of those affected would have to be considered in making future arrangements ; but lest it should be considered impracticable or undesirable to take so much in hands by county surveyors, the author should state that at present his weekly pay sheets average forty, but the mechanical labour that has to be gone through in checking these over would be reduced fully one-half under the proposed system of getting all materials supplied by contract, under bond, with County Boards.

The statement, in conclusion, should not be omitted that, as the County of Dublin is under a special Act of Parliament, these observations are only intended to apply to it so far as it is similarly circumstanced to the rest of Ireland.

#### APPENDIX A.

QUEEN'S COUNTY.		Nos.	
	P. A.		£
APPLICATION FOR ADVANCE.	A.		£
<i>(To be kept clean.)</i>			
	Total	...	£
Date			188

NOTICE.—All Road Contractors requiring advances must apply in this Form, to be had from Assistants. This side (below) to be filled up by Contractors and given or sent to Assistants with postage stamp to forward to County Surveyor. This the Assistants will do, not telling the Contractors, if they ask, whether they will sign or not. If they do not sign, let the reason be given. No attention will be paid to ANY application not fully and properly filled up. Should the Contractor so desire, the Assistant shall do this for him, and if so required, he shall be entitled to *three pence* for each application so filled, for his extra work, and for reading same carefully over, and explaining to Contractor before signature ; this sum to include postage.

**Labour Return only.****Contractor's Address**

## Post Town

day of

188

**To the Queen's County Surveyor; Office, Portarlington.**

SIR,—With reference to my Contract No.                      last Query Book,  
perches, I request an advance, the Materials out, Road, &c.,  
being in accordance with Specification, the last Block I (a)  
and acknowledge having received (b)                      payments since last  
Spring Assizes, amounting to (c) £                      and no more, all  
included.

Since date of (d) I have entirely gone over this Contract, every branch thoroughly from *end to end*, not less than (e) times, at intervals of *not less*\* than Seven days between each going over in any section, doing *substantial* repairs (not including Surfaceman's time, or *intermediate* repairs done between times). On these *substantial repairs* in all these times I expended collectively the fair days' work and full time of more than (f) men, who were entirely engaged working at all or some of the following details:—Cleaning, picking, scuffling, edging, spreading materials, making outlets, or removing mud.

Also (if any) for intermediate repairs done *between* these times I spent over and above the fair days' work of more than (g)

- (a) Insert "now send," "have returned," or "no block."
- (b) Insert the number of payments you received altogether.
- (c) If no advance already made, insert the word "none."
- (d) Insert the words "last payment;" or if none made, the words "Spring Assizes."
- (e) Insert the number of times, which *must not* be less than "four."
- (f) Insert the number of men, which *must not* be less than "twelve."
- (g) If no intermediate repairs, insert the word "none." On very light, sound, well-kept roads, there will not be the same heavy penalties exacted for the absence of surfacemen as on the more important; but in heavy contracts the severest fines will be inflicted, if at any time, when specified, or at any hour, they are found absent from work.

\* The object of this is to prevent men being entered as employed working, say "the day after" the work has been thoroughly gone over, when there would be nothing substantial to do, and their time would mostly be lost. On soft roads where such labour is necessary it should be entered in (g), under the head of *intermediate* repairs.

men, including Surfacemen (if any) in actual labour on the road, not including stone breaking or drawing materials.

I solemnly and sincerely declare the above statement to be entirely true, having myself seen all the work done, and being in the position to swear to its substantial accuracy, if necessary, in every respect.

Signed

Contractor.

I hereby certify that I fully understand, and have carefully read over above before signing it.

Signed

Contractor.

N.B.—The Assistants will be particular in endeavouring to explain that men employed *periodically* on the road, are to be entered *quite distinctly* from surfacemen *continually* working. All roads, at all times during each year, require *special* going over by several men working together, at intervals varying according to circumstances from *once a week* to *once a month*. Such necessary periodic labour should be entered as *substantial* repairs, giving the number of men engaged and counting for each, the number of days he has been working, as one man's work for every day so engaged.

All men *constantly* employed, such as surfacemen, whose business it is to *prevent* roads getting bad, to be entered as "Intermediate repairs," and evidently, the *more* attention thus given constantly, the *less* there will remain to be done in the way of "substantial repairs;" but there must, *even thus*, be always the full time given of at least *twelve men* taken collectively in *not less* than *four* periodic repairs.

Particular credit gained by numerous thorough (or substantial) repairs—not less than three men working *together* at one time going over whole road.

For a road in *fair order*, twelve men thus doing four repairs will give a constantly more uniform and a better road than *twenty* men will do working only once over it within the same period.

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#### RULES WITH REGARD TO ADVANCES.

- 1st. None can legally be made unless the Contract is for over £20.
- 2nd. All payment applications for this work will be carefully put together, and rigidly tested for accuracy when final Certificates being given, and Contractors treated accordingly. The Assistants must *absolutely* refuse to certify for *any* advance unless work generally in accordance with specification, and rules observed. *Incomplete* or badly filled-in applications, or those done in pencil, to be sent back to Contractors, who must apply over again. The Assistants will be particular when inspecting to inquire among large local cesspayers; and if from appearance of road, or result of these inquiries, they have reason to *know* that Contractor's declaration is manifestly *false*, they will enter these facts below accordingly.

- 3d. No more than two thirds full value can ever be advanced for work done. In estimating this for roads, as a rule half Contract price will be taken as full value of labour for the year, assuming work perfect, and the other half as value for full specified materials, and more if required. Fines will be imposed for *all breaches* of Specification, such as neglected road at *any time*, absence of Surfacemen, inferior Materials, or other faults.
- 4th. No more than four Advances will be made in any one year, in addition to Assize payments. None will be made unless over one-fourth specified Materials are out; or after 1st October unless over two-thirds specified Materials are out.
- 5th. When Contract price is much below County Surveyor's estimate, advances will be very cautiously made, as it may become necessary to take work off Contractor's hands at insufficient sum thus still further reduced. Also, in future, unless in special cases, no advances *whatever* will be made "on account" for work done should the Contractor's tender be less by one-sixth than the price allowed at Sessions for doing the work (two pence in the shilling). In this case, he must *wait* for payment until Contract be *fully completed*, and done to the entire satisfaction of County Surveyor. The Contractor's *special attention* is directed to this rule.
- 6th. The County Surveyor declines guaranteeing *any* advances "on account" for *any* work whatever. No Contractor is legally entitled to payment until work *fully completed* at Assizes, and if not then done to the satisfaction of County Surveyor in every respect, and full materials out, also spread as specified—the money may all go in aid.
- 7th. The County Surveyor will give no advance unless the following Certificate is signed by Assistant:—

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ASSISTANT'S CERTIFICATE.

I certify that I have within the last fourteen days completely inspected this Contract No.                      last Query Book                      perches. The work done was then so far *good*, and in general accordance with Specification, with the exceptions referred to (if any) in my report to County Surveyor already forwarded. The above regulations have been complied with, and I consider a total sum not exceeding £        :        : may be granted inclusive of all payments made since last Spring Assizes. I have no reason to believe the Contractor's declaration on the other side is wilfully false, having made full inquiries as far as possible from local cesspayers, in addition to exercising my own judgment on the state of the road, and generally.

Dated this                      day of                      188                      Signed                      C.S.A.

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ASSISTANT'S REPORT AND GENERAL REMARKS.

Contract taken at	Assizes, 188
Contractor's price	per perch per annum
Price allowed at Sessions	per perch per annum.

Signed,                      C.S.A

N.B.—All Contractors, on demand, to be supplied with copies of this form.

## APPENDIX B.

These Blocks to be kept clean, cut off, and forwarded with application through Assistant when asking another Advance, otherwise *no more* will be given. Hedge Notices to be had from Assistants. Heavy penalties will be inflicted in *all* cases where injurious or obstructive hedges not cut, or owners summoned before magistrates, to compel them to do so; in this case the Contractor to state below the Order made; also, generally, he must state what he *has done* to remedy matters complained of in County Surveyor's observations where marked or underlined. Fines inflicted for *all* these breaches, which will be continuously increased the longer the faults complained of that *can* be remedied are left undone. The Assistants will help Contractor to fill this statement, if required to fill the Application for Advance for him.

Date Inspected	County Surveyor's Observations. {Nos. }	On Sections	Contractor's Statement
	1 Materials short ... .. 2 Do. Quality, bad, inferior, mixed, soft, dirty ... .. 3 Materials not screened, as specified; gravel too small, too large 4 Materials. Quality and size shown on spreading ... .. 5 Materials. Spreading delayed, in drills 6 Floors—Uneven, too few; so uneven looks like fraud ... .. 7 Road Surface—Water worn, too flat on hills, sink tables ... .. 8 Road Surface—Too round in level parts, side piece, raise tables ... .. 9 Road Surface—Very bad, bad, muddy, tracked, rutted, neglected ... .. 10 Road Surface—Showing big stones; pick up and refill ... .. 11 Road Surface—Uneven, lumpy, coarse; pick, level, smooth ... .. 12 Surfaceman, as specified, not seen working ... .. 13 Margins—not cleaned, not lined 14 Tables not cleaned, not full width 15 Side cuts, side drains—not made, 16 Pipes through fences—under path—new required, badly built, choked ... 17 Road sides, not embanked full width—dug, rooted by pigs, rubbish on ...		day of 188  To County Surveyor.  SIR, In forwarding this block, together with my application for another Advance, I have carefully noted the various points on this sheet to which my attention has been directed; and in order to remedy same as far as can be I have*  <hr/> * Here state what you have done, neatly written in ink. If nothing particular pointed out you need not fill this side, but forward as it is; otherwise, not filling up, or getting filled up, and signing, will be taken to imply "further neglect."

Date Inspected	County Surveyor's Observations { Nos. }	On Sections	Contractor's Statement
	18 Encroachments—Fences made ... 19 Footpath—Clip hedges, widen, gravel, too low, weeds, bad range—fix edges, curbs, channel; very neglected ... 20 Hedges—Cut, breast, get out, or serve notice to cut immediately, and summon owner, if not done; obstructing, injuring by shade—boughs overhanging, get out ... 21 Weeds not cut; channels through, or to or from gulleys and bridges, not cleared, or caused to be kept clear ... 22 Bridges and gulleys damaged since contract entered into, not repaired, getting worse—repair immediately SPECIAL—  Paid since Spring Assizes, £ Now certified ... .. £ Total ... .. £  Date,		Signed,  Contractor.

Mr. DUFFIN said (through the Secretary)—Mr. White had omitted in his enumeration one most important purpose for which county cess tax is levied—viz., for guarantees for railways and tramways—and one which is likely to be extended. In his county (Waterford) a sum of nearly £13,000 was annually raised for this purpose. There was room for considerable amendment in these cases. The guarantors had really no control over the construction, maintenance, or working of such lines. Once the guarantee was given they had simply to pay the money when called on to do so. It is easy to see that the guarantors might be greatly wronged. In the Tramways Act of 1883 an attempt had been made to remedy this defect, by giving the County Surveyors certain powers of inspection during construction, and afterwards giving the grand juries powers to have a yearly or half-yearly inspection and report from them.

He could not agree with Mr. White in calling the grand juries "taxing bodies." Under the original Act of 6 & 7 Wm. IV. the grand jury (with a few necessary exceptions) cannot initiate any taxation, but all presentments must first come before the presentment sessions, and any presentment which does not pass the sessions does not appear before the grand jury; they can then only pass or reject, and if they twice reject an application there is an appeal. They cannot therefore be strictly called a taxing body. Subsequent Acts have given the power, and notably the Tramway Act of 1883, which gives them the power of initiating the guarantee, and he believed this has tended to impede the working of the Act.

Mr. White's figures, in which he shows that considerably over half a million of money is annually spent on maintenance works, show the great importance of the subject to the community. He wished Mr. White had given them a comparative statement showing the increase in these works. As an illustration he mentioned one barony in his county in which, in 1838, there were 25 miles of roads under maintenance contract; there were now 100 miles. With regard to certifying for work at sessions before it has really been executed, the difficulty can be partly removed, by holding the sessions as near as possible to assizes.

In County Waterford all maintenance contracts commence in July, so that the first term of the contract includes the annual supply of metal, and there is no danger of the contractor being overpaid at the Spring Assizes following.

The inequality of the long and short half-years might readily be removed by levying two-thirds of the amount of maintenance contracts at Spring Assizes, and the remainder at Summer.

Part-payment of contractors would give additional trouble to County Surveyors, and would be difficult to arrange, but would of course be an advantage to contractors, and is done to some extent in some counties. It is, no doubt, very hard to

give nothing for his work to a man who has done a certain amount. He believes advances of payment would be very useful and tend to lessen the expense of maintenance, but the system described by Mr. White appears to him very cumbersome. As soon as the annual supply of metal had been delivered and measured, an advance might be made, and again at each sessions, to all contractors to whom certificates had been granted.

As to remedies against defaulters, he found the 54th section, enabling County Surveyors to do the work, most effective, but there was a difficulty in providing funds. If in any new legislation adequate provision was made for this, and if, in accepting tenders, the sessions had power to refuse any which were less than half the estimated price, so that the full amount estimated could be recovered from the securities, it would give ample powers.

He believed it right in principle, that only double the amount of the yearly sum could be recovered from the securities. It would not be just to recover the sum necessary to maintain the road four or five years hence. The bond should be estreated and the contract terminate, and it could then be relet.

In County Waterford a clause is inserted in the bond which empowers the grand jury to terminate the contract, should it not be fulfilled, at any time. He finds this of great use in getting rid of bad contractors.

With regard to works given in charge to County Surveyor, his experience had been that in maintenance contracts the work could be much better and more economically done. When roads have been in his hands for some time, he finds he can maintain them for prices at which contractors will not tender. He had long been of opinion that a great economy could be effected in maintenance of roads by giving all main roads in charge to County Surveyors, and by using machinery.



It would be most desirable that some classes of special works should be given in charge to County Surveyors, as it is almost impossible to get difficult or critical works properly carried out by ignorant contractors. Yet the County Surveyor is at a great disadvantage in such works, as he has no plant or tools, and has to purchase such as he requires for each work, and sell afterwards at a great loss, although sometimes he can sell them to another work.

It would be very desirable for counties to be empowered to purchase tools and machinery; this would also enable them to purchase stone-breaking machinery and road rollers.

As to Mr. White's proposal to supply the metal by contract, and to allow the County Surveyor to supply labour, he believed this would result in great economy and improvement in the roads. By slight changes in the staff the extra trouble of pay-sheets could be easily arranged for. If the money were raised on estimate, and not, as now, for each contract, matters would be simplified, and any excess for one work would pay for the deficiency on another.

Mr. T. WILLSON said—If the author be so good as to give the following information, he believed it will be of some use in discussing his paper:—

1. What check does he propose, or does he now use, to secure correct returns from the overseers, of material used, of cartage, of quarry fees, and of the time of the timekeepers, overseers, and men employed?

2. How are payments made, and, as these payments are in small items, how does he secure the proper vouchers for audit?

3. What time does it take to check the returns, in pay-sheets, quarry fees, &c., men's time, &c., say per 40 sheets, so as to have an efficient check, not simply a signing of these papers?

4. How does he know when to enter on a road for repairs; if this duty is performed by your assistants (say 3 assistants to

1,000 miles of road), how much of their time will it occupy, and what will be the annual cost of their necessary car-hire that they will have to pay out of a maximum salary of £80 a year?

5. Under a half-contract system, say for 1,000 miles of road, how much of the surveyor's time must be spent overseeing the overseers, assistants, and timekeepers, as well as in checking returns, &c., and what would be the cost of car-hire, &c., for this purpose?

6. Has he many new roads or any tramways in his county, and what time does it take for their supervision, and for the necessary half-yearly arbitration and reports, and how will he provide for weekly payments when absent on the above duties, probably having to remain some days in another county, as in the case of the Clogher Valley Tramway?

7. Can he give any idea of the cost of the proposed half-contract system for 1,000 miles of road—(1) To the three assistants; (2) to the county surveyor; (3) for the necessary overseers; (4) for the necessary timekeepers; (5) for the necessary pay-clerks?

8. Is the charge of three pence to be paid by a contractor to the assistant for filling forms, under the present system, legal, and under what Act?

9. When his assistant makes the inquiries from local cess-payers, indicated in the paper, if the cesspayers (which is very probable) make an accusation of fraud against a contractor, what does he do? If the surveyor refuse payment on such a ground, will the law support him?

10. How does he enforce the fines referred to for breach of specification, and under what Act?

11. Has he in his county a provision for the withdrawal of his certificate for neglect between the road sessions and the meeting of the grand jury?

The system in the County Fermanagh is purely a contract system—it works fairly, payments are signed at the road

sessions for works then completed, with a provision for withdrawal for neglect between the sessions and the following assizes. In the case of roads fairly attended to, but not fully completed, the chairman of the sessions will sign—the surveyor's certificate not being given until the works are fully completed; in cases of failure certificates are disallowed at the road sessions and the moneys expended on the roads.

Mr. Willson believed two presentment sessions for each barony and two meetings of the grand jury or county board in the year to be quite sufficient. Under the present system he had not found that serious faults have to be passed over in order to pay contractors in full, and, moreover, it is his experience that the cesspayers get full and more than full value for the moneys presented for the various works. He considered it to be a bad system to sign all certificates in full at the road sessions (by the chairman of the sessions), as it practically puts both bad and fair contractors on an equal footing; and he thought that no advances except the half-yearly payments should be given on maintenance contracts, and that advances should, in the case of other works, only be made when the amount exceeds £40 instead of £20; all public works should be executed by public competition or by sub-contract, and day labour should only be resorted to as a last resource; the lowest tender should not necessarily be accepted, as this encourages reckless and unfair proposals for works, the acceptance of which must lead to neglect and failure. The 19 & 20 of Vic., cap. 63, sec. 17, is practically unworkable, due to the necessity of having two magistrates present, and to the fact of having to summons a second time, as well as the want of funds available for carrying out the necessary works in case of obtaining a decree. He was strongly inclined to hold that no work should be presented for directly in the name of the surveyor, but in that of the secretary, who should be responsible for the payments made under such presentments, thus making, as

originally intended, the duties of the surveyor of a purely engineering and executive character; no contracts or tenders should be taken by the County Surveyor, as this would lead to endless disputes and accusations of favouritism; nor should he in any way be made a contractor, his present duties being ample.

The present system has, on the whole, worked fairly, and has been decidedly economical, and Mr. Willson believed it to be much preferable to any half-contract system such as indicated. For first, the half-contract system will be more expensive—it appears that the annual expenditure under such a system will be about £13,772 for 1,000 miles of roads, whereas in this county the contract system maintains 1,000 miles for £11,250 a year, giving a considerable balance in favour of the contract system. Secondly, there would be considerable increase in the cost of supervision, in the payment of a staff of overseers, &c., timekeepers and pay-clerks, as well as a great difficulty in keeping an efficient check over the timekeepers and overseers.

An objection arises from the number of pay-sheets to be checked. The author takes each contract at 4 miles long—3 miles is a more probable length—which gives  $334 \times 20 = 6,680$  annual pay-sheets = 129 per week. Say at a quarter of an hour each to check, certify for, and enter expenditure = 32 hours per week = 4 days a week, what time is there left for the real duties of the surveyor? The author has written to me that he can perform this duty for 40 sheets in two hours, or three minutes to each sheet; but I do not see how one can efficiently check these pay-sheets, certify, and enter expenditure in that time.

In order to know when to enter upon each contract, they must be inspected by the assistant surveyors—say, three assistant surveyors to 1,000 miles of roads, that is one to 333 miles to see once at least every month, that is (driving 25

miles a day) about 116 days' driving in the year for this purpose alone, costing £84 a year for each assistant, or £252 a year for 1,000 miles of roads for car-hire over the whole county, tending to increase the cost of supervision.

In the various returns, pay-sheets, &c., the surveyor will be left greatly at the mercy of the overseers and timekeepers as to the correctness of their returns; and, after a time, when, through the extent of works thrown on his hands, the workmen have the surveyor more or less in their power, strikes will be sure to arise; and as there will then be no check to their demands arising from wholesome competition, these strikes will cause increased expenditure, and, most probably, inconvenience and dissatisfaction. In a large county of 1,500 to 2,000 miles of roads he feared such a system could not be managed under one surveyor; and in any county the constant supervision necessary over these day-labourers and gangers, &c., by the County Surveyor will occupy all his time, reducing him to a kind of check clerk, and leaving him no time for his other duties, such as the supervision of bridges, new roads, piers, line cuttings, tramways, and other county works, as well as for the preparation of necessary plans and specifications and reports on proposed and existing works, which require some time, as will appear from the fact that during last year (1885) in this county there were 304 applications for works before 16 road sessions, including 4,551 perches of new roads, the proposed cost of the new roads alone amounting to £11,791 15s., to be examined into and reported on, &c., as to the necessity, utility, and cost of such works, besides preparing the necessary plans and specifications; in addition to which, in this county, there is the necessary supervision of tramway construction works, the half-yearly arbitration or audit for the amount of guarantee to be paid by the guaranteeing districts, and the different reports on the line, rolling stock, &c., to the grand jury and Board of Works, &c.

Changes, no doubt, will be made in the administration of the fiscal business of grand juries, not so much because they are required as that the local cesspayers wish to have complete control of all local matters.

Mr. LYNAM, through the Hon. Secretary, said—Every County Surveyor must feel indebted to Mr. White for his able and exhaustive paper.

His suggestion of a “half-contract system,” however, he would be very sorry to see adopted. He admits that the present system works fairly well on minor roads; so that at least the alteration to the proposed new system should be left optional with the special sessions, if thought desirable, on particular main roads with heavy traffic. Mr. Lynam saw no necessity for the change; on the contrary, he thought it would lead to abuses much worse than any which now exist.

The average expenditure of a County Surveyor being £20,000 per annum, Mr. White proposes that about £7,500 should be expended on hired labour under the superintendence of the surveyor.

He has not yet had three years’ experience as a County Surveyor, but for five years in the Ceylon Public Works he expended on roads about £10,000 per annum, chiefly in hired labour, and he has had considerable experience of hired labour in this country.

The result of his experience is that no overseer on £2 or £3 per week, in this or any other country, no matter what security he may give, can be trusted with the uncontrolled supervision of his party. If not closely looked after, even the most honest and well-meaning overseers become demoralised, or are intimidated by their men. After a time idling begins, men are entered on the pay-lists for more time than they actually work, then false names are entered of men who never worked at all, or who only made a pretence of work. From

small beginnings, which pass unpunished, these evils increase to an almost incredible extent.

It would be essential for a surveyor to inspect each party, and call the roll once a fortnight, at uncertain intervals, also to make a careful measurement of the work done every month. Even with these safeguards he has often been obliged to dismiss overseers, and one man got two years' imprisonment for fraud.

The main precaution is a monthly measurement of the work done, but labour on roads (excluding supply of materials) is just of that kind which is most difficult to task. Even at the best the ordinary hired labourer will not do half the work that would be done by a contractor working for himself.

Mr. White calculates that the only extra work thrown on County Surveyors by the adoption of his system would be the checking of about one hundred pay lists per week in the office, but this (although essential) would be only a trifling matter compared with inspections required on roads to prevent idling and fraud. He believes that the "half-contract system" would quadruple the labour of supervision, and that on the average a County Surveyor could not honestly undertake more than one-fourth of his present expenditure.

He wished to ask Mr. White if, in his opinion, he could conscientiously entrust to overseers the expenditure of £7,500 per annum, and confine his personal supervision to checking the arithmetic of the pay lists in his office, with no more inspection than at present.

On the public at large the moral effect of a large expenditure on hired labour is very considerable. Everyone knows the unpleasant remarks which are made by passers-by if a hired labourer is seen even to rest for a moment. It is quite true that the main object of every hired labourer is to "put in his day." Reports spread rapidly on such subjects even if there be little or no foundation for them, and an engineer who

took a pride in his work, and had a scattered district to look after such as this (eleven hundred square miles in extent), would soon find his position unbearable—in fact, no more certain mode could be found to bring county work into general disrepute.

As regards the condition of the roads, he believes that equally good, if not better, results might be obtained by a more extended use of the 54th section of the Grand Jury Act. The objections stated above do not apply to hired labour paid for at the contractor's expense. The expenditure would be limited in time and amount, and the more costly it would be the sharper the lesson to the contractor not to neglect his work in future.

In this district the 54th section of the Grand Jury Act is unfortunately a dead letter owing to objections on the part of the county treasurer to pay the overseers employed. Defaulting contractors are proceeded against at petty sessions under the Act 19 & 20 Vic., chap. 63, sec. 17. The police always execute the warrants. In cases where the police find no goods to seize the contract is cancelled by the next grand jury, as every maintenance contract contains a avoidance clause in case of the surveyor's certificate being refused for any half-year. In two years over eight hundred summonses have been issued, and about fifty decrees executed, with excellent results. This mode of procedure, however, is too slow for day to day neglect on main roads, which would require action under the 54th section of the Grand Jury Act.

As far as his experience goes, he believes that *three* alterations are required in existing legal remedies against defaulting road contractors:—

1. The amount of the contractor's bond should be double the amount allowed by special sessions—not, as at present, double the amount of the contractor's tender.

2. The fact that the police are bound to execute warrants



under the Act 19 & 20 Vic., chap. 63, sec. 17 (which appears to be doubted in other counties), should be placed beyond dispute.

3. The 54th section of the Grand Jury Act should be made workable by authorising a presentment to the county treasurer as a fund to meet payments to the overseers employed, to be paid as required on the County Surveyor's certificate.

MR. WHITE, in reply, said :—The various points which have been raised referred nearly altogether to the suggestion made of substituting a “half-contract” system—or of giving power to do so to grand juries or county boards—to replace that existing for the maintenance of public roads in Ireland. In answer to these questions he proposed—

1. To explain what would appear the most effectual mode of carrying out the suggestion.

2. To give his own experience of somewhat similar work where the manual and horse labour is hired by day, and materials are sometimes obtained by contract and sometimes by day labour.

3. To give explanations and, where possible, to meet objections.

1. It is not proposed to extend the principle to any road or work of the nature of a special, only to the maintenance of roads for a year or term of years. And, admitting that the present contract system works fairly well for light minor roads, it might be a matter for consideration whether they could safely be excepted or not. The author has doubts on this matter, and does not think a double arrangement would give satisfaction in any county. However, in proportion as the public roads become important, carrying heavier traffic, it becomes more and more difficult to deal with defaulting contractors for their repair, and in many cases it becomes impossible. This will be again referred to when answering objections.

In the county taken for illustration in the text it has been assumed there are 1,000 miles of roads, and that the annual cost is £15,000. This estimate, though a little high, will suit for illustration. It will also be assumed that the entire work is to be carried out under the half-contract system. Taking the case of any single road requiring maintenance repairs, application should be made as usual to the presentment sessions; £100 per annum is allowed for, say, five years; this amount is levied half-yearly, and the amount is presented direct to the county treasurer; a specification is written for the supply of materials, with conditions, penalties, &c.; tenders are invited from contractors, which being as hitherto considered at adjourned sessions, a contractor is selected, bonds are signed, and the agreement is ratified by the next grand jury or county board. The rest of the money so presented is expended in hired labour; and at the end of each year should any remain over unexpended it should go in aid of the rates or be carried forward. And it is proposed for the advantage of the contractors that the 128th section of the 6 & 7 William IV. be made universal in its application, so as to enable them (when advisable) to get money reasonably often. However, for a contract commencing in March—the beat period—they should have no legal claim to payment till the end of each year.

It is not suggested that any money presentments be made to the contractors direct. This would cause great confusion in the accounts, as they would only be paid (with due precautions) in proportion to the quantity of materials delivered, which might vary somewhat in each year. In this way every road for maintenance would be dealt with—roughly speaking, £7,500 going towards materials, and £7,500 towards labour.

With regard to the former item, it is not proposed to lay down rigidly the conditions to be fulfilled by contractors, &c.; these should be regulated by circumstances; but it is

necessary to show that their work can be simply and accurately measured.

Coming back to the road presentment for £100 annually, taken for illustration, beginning March Assizes, it will be assumed to require £50 worth of materials, as supplied by contractor in each year, varying more or less slightly, according to the seasons, traffic, &c. Suppose the contractor whose tender is accepted agrees to supply this at 2s. 6d. per ton, and that it is estimated 400 tons will annually be required, then it should be so arranged that about nine-tenths of this should be put out all together for measurement by the 1st September along the road, and a due proportion thereof put out in previous months, say in May and July. These various accumulations should never be touched or interfered with until measurement time came round, when they would be measured independently both by the overseer and assistant for the district.

The remaining one-tenth of the materials would probably be required to be spread off direct between March and the 1st September. The measurement of this could easily be done in the quarry, the stone being carted direct and spread off as wanted; but by no means should these materials be permitted to become mixed with the others.

An arrangement like this would enable the estimated quantity to be somewhat increased or reduced, so as to produce the best results from apportionment of the amount to be spent between materials and labour. The assistants in their report-book should enter as measured by overseers all materials "occasionally" supplied previous to the 1st September, and when desirable check these themselves; but for the winter or heavy measurement, all road materials, as hitherto, should be measured by them direct, and also by the overseers. These observations will, it is believed, show that no practical difficulties present themselves in dealing with contractors for materials.

If it was found that such contractors were not giving satisfaction—say, for instance (to allow time to get them elsewhere), a contractor who was bound to have half the quantity out in July had not even commenced to do anything, he could be proceeded against by a ten days' notice.

We now come to the question of labour. In the county or district assumed it may be estimated that the 1,000 miles of roads would require, for proper supervision, five assistants and ten overseers—the author for 358 miles in charge finds five overseers necessary; but then they have the labour of getting materials supplied. Each overseer should report on his district once a fortnight, and, in a special manner, on those roads for which pay-sheets are sent in, with dates of inspection on each abstract. Under them are gangers, having from two to six roads each to go over each fortnight. These gangers are supplied with tools, barrows, &c., for themselves and the men under them. A list of these tools (county property) should be returned by each overseer on proper forms every fortnight.

In order to prevent idleness, each overseer should often, unexpectedly, come upon the gangers and their men; and it is essential, unless under most peculiar circumstances, that the men should work in gangs of not less than from three to six, together with and under the direct supervision of the gangers. These men act as timekeepers also; and the penalty of instant dismissal should follow any deliberate wrong entry in their time-sheets, which can be made very easy to fill, and which, every fortnight, should be given to the overseers, to enable them to make out pay-sheets. Together with these pay-sheets, abstracts of same should be sent, arranged in regular order, to the surveyor, and kept by him for reference as to work done upon each road, these various district returns being kept separately.

The duties of assistants, who should as at present receive fixed

salaries, would be to see after contractors for materials, make measurements, also to report on specials, new applications, and direct attention to roads requiring most repairs; and, in a most particular manner, they should include, every fortnight, detailed reports on all roads in their district for which pay-sheets were forwarded the fortnight before. This would be an effectual check upon the surveyor's men, and render it impossible for irregularities on any road to pass unnoticed, against which there would be the following guarantees:—(1) The surveyor's unexpected visits; (2) the assistants' regular inspections; (3) the overseers' reports; (4) the precarious tenure of their office; (5) the overseers' bonds; (6) public feeling in the locality.\*

In the county assumed each overseer would have an average of 100 miles to attend to, about one-third of which could be gone over successively each fortnight, or from 33 to 40 miles; this he could readily manage, so as to look closely after the men engaged in the work.

This is the outline for a complete working system, and there would be no difficulty about the details; that in actual use here is very similar as far as it can be, but is not so perfect in important respects.

Next, as to relative annual expenditure under each system.

The cost of 1,000 miles being estimated at £15,000, five assistants at £80 would bring it to £15,400. Now, if we take as a standard for relative cost of road repairs the prices calculated from the presentment-book here of Summer Assizes, 1885, it is in the ratio of £13·8 to £12·6, or as £15,000 to £13,000 nearly; and as the assistants are supposed to be increased from three to five, the difference would appear to be in the proportion of £15,400 to £13,240. This is only

\* The further guarantee might, perhaps, be added—to require all overseers, when forwarding returns, to transmit sworn declarations as to their accuracy, amounts due, men's names, work done, &c.

apparent, however, for the work would be much better done ; and after a short time, when, by care and attention, roads became improved, the estimates could readily be reduced. Moreover, the 357·6 miles in charge in the Queen's County include nearly all those roads with heavy traffic in the district. This largely accounts for disproportion in cost. The cost of supplying materials being under mixed local arrangements, renders it higher than it would be, if supplied as suggested.

In regard to the author's personal experience of works in charge, a good deal has already been stated in comparing the relative cost. About one-third of the entire mileage is at present in charge ; 711 miles in contractor's hands, at an estimated cost annually, by tender, of £8,987 7s. 6d. ; the cost of the 357·6 miles in charge being £4,917 6s. 8d.

The interesting and important statement may here be made that the author finds, in a locality where works in charge are well established, it has a wonderful effect upon surrounding contractors, and tends to a competition of systems, and, in a considerable number of cases, the contractors pay great attention to their work. This cannot, however, be adduced as an argument in favour of the existing laws ; it is a coincidence merely, and does not meet extreme cases. Under these circumstances, whenever it becomes necessary, owing to neglect, to take up a contractor's road, under the 54th section, there is comparatively little difficulty ; the machinery is ready to put in motion at once, and the cost of supervision is reduced to a minimum. Under less favourable conditions very great difficulties have to be encountered, especially where the price is small.

Next, it only remains for the author to endeavour to give explanations, and, if possible, to answer objections.

Mr. Gray thinks in practice it would be impossible to expect maintenance contractors for roads to give adequate security for a term of years at double the amount of contract.

price for the whole term. The author quite agrees with him; but the present arrangement is opposed to all rational notions. He also considers the principal difficulties to arise from grand juries being bound to accept tenders manifestly too low, from which it might be inferred that, if this could be prevented, results would be fairly good. He agrees with Mr. Gray that the effect would be beneficial to a certain extent, yet he believes that, even if it could be accomplished, the remedy would not go far enough, and this for the following reasons:—

1. It will be conceded that, for a general system capable of giving satisfaction, it ought, in a particular manner, to be made applicable to main roads, and the more so in proportion to their traffic and importance.

2. Let it also be conceded that, for roads of this class, surface defects, as they appear, should be remedied at *once*, and should not be permitted, especially in soft weather, to remain, getting gradually worse, for a longer period, at the very most, than two or three days.

If these fundamental principles be admitted, it becomes easy to demonstrate that the existing arrangements are far from satisfactory, and it may be safely laid down that any system not based upon these principles must necessarily be bad, and unsuitable for general public purposes.

It has been already shown that, for roads of this class, the remedy applicable to defaulters least objectionable is contained in the 54th section of the 6 & 7 Wm. IV., cap. 116; but even here nothing can legally be done for ten days, practically for a *fortnight* or *longer*. And, further, the contractor may, *during each year, legally keep his road generally as best suits his convenience*, provided that, whenever inspection time comes round, he conforms to ten days' notice.

And, moreover, when the road is, under this section, taken up, great caution is essential, for it appears that, legally, the contractor has vested interest in the presentment, even though

he does nothing, and, to use that appropriate and new classic phrase, likes to "keep a grip on it."

With regard to the special arrangements in the County of Dublin, it would appear that road contractors receive payment through committees, who require no certificates from the County Surveyors. It would be interesting to know whether their surveyors' suggestions are always acted upon by them, and, if not, the effect upon contractors; also, the extent (if any) to which endeavours are made to influence road wardens, and with what result; also, whether they are competent to decide for themselves in case they disagree with their surveyor.

In reply to Mr. Willson.—Payment to contractors for materials should, as explained, come out of presentments made to the treasurer. With regard to repairing roads and spreading materials, experienced overseers know perfectly well how often this is necessary in proportion to the amount allowed, and require few directions on the subject. With regard to assistants the rule in his county is that they report on 10 miles a day, and in general they inspect each contract in their district from four to ten times annually—the mileage under each assistant averages 350. He could not say what their car hire should be; his assistants all have private vehicles. It is not believed the proposed system would materially increase the number of inspections at present required to be made of the roads by county surveyors. The checking of pay-sheets is very simple, the different sums being, in the terms of the Act, made out to contractors, artificers, and workmen. Contractors generally supply or draw materials when not obtained by day's work, the artificers supply tools and implements, and the workmen perform the labour, and are sub-classified into overseer and labourers, including gangers. The number of entries on each pay-sheet varies from about three to about thirty—an average might be ten. If a mistake is made through carelessness, the overseer should make



it good out of his wages. If through unavoidable causes such happened, we are apparently in the same position as at present should anything similar occur in dealing with contractors. The author has not had much experience of mistakes, but remembers once being on the point of certifying for a small bridge, which, at the time, appeared perfectly well done, but it fell soon afterwards. At present it takes about two hours to check the pay sheets, entering the successive expenditure for each number as certified on proper forms to enable the usual declaration to be made each Assizes. As to the working of this county, with regard to advances, each assistant must use his own judgment, if anything appears wrong no payment is allowed until the contrary is shown. With regard to the legality of the assistants filling the forms, &c., it is not their business at all, unless for the convenience of the contractor at their own request. At present, however, most contractors, or a great many, fill the forms properly themselves. Payment is made fortnightly for roads in charge, each week in alternate districts, by pay clerks sent by treasurer; there is a standing order as follows :—

Ordered—"That the secretary to grand jury do pay on the works to contractors, artificers, and workmen such sums as may be duly certified by the County Surveyor, for works given him in charge under 6 & 7 Wm. IV., c. 116, and 20 & 21 Vic., c. 15, sec. 2, as well as work done by him under 6 & 7 Wm. IV., c. 116, secs. 54 and 146, not exceeding the amount presented for such work, and the secretary is hereby authorised to draw checks in his own favour for the amount required to enable him to pay such contractors, artificers, and workmen, and that he (the secretary) be allowed the sum of nine pence in the pound out of such presentment as a remuneration to the person employed by him for the payment on the spot of the persons engaged in such work."

Mr. Lynam appears to have formed very unfavourable

opinions with regard to hired compared with contract labour; he also seems to think that overseers could never be depended upon to remain honest—of course they would require to be looked after as much as ordinary men. My experience has been different from his; moreover, under the proposed guarantees it would be almost impossible for matters to go astray. Three of the overseers here have had from six to, it is believed, eight or nine years' service, and the author would have either seen or heard something to that effect if they were unreliable, and they executed no bonds. One would also infer from Mr. Lynam's observations that the present assistants are not open to the same suspicion in reporting on contractors; as a matter of fact, they are very often suspected by the public, as a rule, unjustly, but there is nothing to be said of one class in this respect that will not apply equally to the other. Moreover, under the proposed arrangement one would act as a most useful check upon the other. The author is aware of one assistant who had to be dismissed not long ago for taking bribes; this was not discovered until much public loss had been occasioned.

Mr. Lynam's unfavourable opinion of hired compared with contract work may be perfectly true for works specific in their nature, the only condition of which is to fulfil certain requirements—such as to build a house, or make a railway—on a fixed date. Even in these cases and for most ordinary specials, hired labour must be paid for and utilised by the contractor, on which he necessarily expects a profit, but maintenance contracts running for a term of from one to seven years, requiring constant attention, are completely different to deal with.

Mr. Lynam makes a very important statement as to his experience of proceedings being instituted before petty sessions against defaulters under the 19 & 20 Vic., c. 63, s. 17, where the police execute these warrants. If no assets are available, the contract is cancelled by next grand jury. He states that within

the last two years over 800 summonses have been issued with excellent results, and about fifty decrees executed—but this mode of procedure is too slow for day to day neglect on main roads which require action under the 54th section.

Commenting on the above, if no assets are available, no one is responsible, and from July to March there must be total neglect. Moreover, it is exceedingly doubtful that a whole year must not elapse, no fresh presentment being legally obtainable until after the other has been cancelled. No doubt the 800 summonses must have had a great moral effect, but in the cases where 50 decrees have been executed, also in the numerous others for which probably he holds decrees not executed, Mr. Lynam cannot prosecute them any more during the whole term of the contract for the unexpired years to run; he must be satisfied with what he has got, which must be altogether insufficient to meet future wants, in the event of neglect. These contractors are perfectly safe in doing nothing henceforth, except that they must be content to expect no payment for work not done. No decree can be obtained more than once upon the original bond; it is then a great advantage to contractors for heavy roads, of which they find prices to be too small, to arrange to be thus decreed *early* in their term. The road may not then be too bad, and a small decree may only be given against them. Attention is again directed to remarks relating to the bonds which may extend to from one to seven years of contract.

In reply to Mr. Duffin, Mr. White regretted the accidental omission of railway and tramway guarantees—the latter subject is in its infancy; regarding the former, they are only occasional presentments, and are included in tabulated expenditure among presentments other than public works, so that it makes no practical difference; the author agrees with his general observations on the subject. Mr. Duffin considers grand juries cannot, strictly speaking, be called taxing bodies—

his reasons may or may not be deemed conclusive—no doubt they only originate taxation in some instances, but the originating court, practically, is composed of grand jurors and associated cesspayers, nominated by grand juries to act, and all presentments must pass the grand jury before becoming law. With regard to the difficulty of having to certify at sessions for work that cannot be completed until afterwards, the arrangements adopted in Waterford are ingenious, but as they do not meet the case the principle must be objected to. His suggestion that for maintenance contracts the inequality of work during long and short half years should be remedied by levying two-thirds of amount during one period, and the balance during the other, should be favourably received; the granting of advances to contractors is not very troublesome, and has many advantages, including the necessity of numerous inspections by assistants. As regards defaulters, he agrees that the 54th section is the most effective, and Mr. Duffin's idea that the presentment sessions should be given power to refuse to consider tenders under half the estimated cost, would be useful. Here, however, it would not often require to be acted upon. The author had not been aware, relative to proceedings instituted at petty sessions, of the decision given by the Court of Queen's Bench (*Stokes v. Buckley*)—it is useful to know, but it will not, it is believed, materially tend to public advantage.

The author entirely concurs with Mr. Duffin's concluding remarks.

Finally, as already expressed, it is not presumed to put forward these ideas as being the best; further inquiry will be necessary; but enough, it is believed, has been said to demonstrate that the crude antiquated notions of 52 years ago, on these subjects, should be replaced by a system more adapted to the growing intelligence of the present age, and to meet the full requirements of the entire country.

[13th January, 1886.]

J. A. F. ASPINALL, President,  
in the Chair.

The following Candidates were balloted for and duly elected, viz.:—

ROBERT CAREW ARMSTRONG, as Member, WILLIAM PATRICK HADE, as Associate.

The discussion upon the paper "County Work in Ireland in Relation to the Grand Jury Laws," by H. V. WHITE, Member, was resumed and concluded.

THE PORT AND HARBOUR OF WATERFORD. By JAMES OTWAY, Member.

[Plate I.]

THOUGH an account of Waterford Harbour may be of some slight interest to the members of the Institution, the writer feels an apology must be made for the want of novelty in this paper, as it does not embrace the history of any important works.

Unlike the cases of the Clyde, Tyne, and many other centres of water-borne commerce, nature has been the chief worker. There are few other ports in the Kingdom (if any) where, at 18 miles from the open sea, vessels drawing 23 feet of water can lie alongside their discharging berths, as a result from such a small expenditure of money.

The City of Waterford is situated on the River Suir, about  $5\frac{1}{2}$  miles above its junction with the River Barrow at Cheek Point. Just below the junction of the rivers the waterway is, approximately, 2,400 feet in width at high water, gradually increasing from this point until it attains the breadth of three

miles at the entrance to the harbour, between Hook Tower and Dunmore East.

The jurisdiction of the Waterford Harbour Commissioners, who are the custodians of the port, extends from a line drawn from Hook Tower to Swine Head, up to Granagh Castle, about two miles above the City of Waterford.

It will, perhaps, be most suitable and convenient to divide the consideration of Waterford Harbour into two divisions. (1) That portion of the River Suir which extends from the City of Waterford down to Cheek Point, designating this as the "Port of Waterford." (2) The estuary from the junction of the Rivers Suir and Barrow at Cheek Point to the open sea at the Tower of Hook, calling this lower division the "Harbour of Waterford."

The harbour of Waterford, situated about 60 miles to the north-east of Queenstown, and 120 miles south of Kingstown, is the only port between these places capable of affording safe anchorage to vessels of large size. It is within a short distance of the track of the great number of vessels passing south; and these include, it is needless to say, a considerable portion of the mercantile marine trading from Liverpool, Glasgow, Dublin, Belfast, and other ports situated on the east coast of Ireland and west coast of England and Scotland. As a harbour of refuge it thus occupies a most important position, geographically considered; and nature has also adapted it in every respect for this purpose, there being good holding ground for vessels in any number, and of any draught, above Passage; the only obstacle to a clear run in with the prevailing winds (and those with which the coast would be dangerous), viz., S.W. to S.E., is a shoal, commonly called "Duncannon Shoal," which lies across the entrance inside Creadan Head, and on which at present there is only, in some parts, about 13 feet at low water spring tides, in others the depths varying from 14 feet to 19 feet.

The deepening of a channel through this shoal has, at different times, engaged the attention of Select Committees and of a Royal Commission. In 1857 the Select Committee of that date said; "There are no two spots in the whole of the United Kingdom at which good harbours of refuge could be got at so small an outlay as at Waterford and Carlingford; £20,000 laid out on each of these would render them navigable at all times for the greater part of the vessels that navigate the Irish seas. Those would especially include the whole of the foreign trade to and from Liverpool, as well as all the other ports on the west coast of England. Your Committee has no hesitation in expressing its opinion in favour of these particular works."

In 1859 a Royal Commission expressed a similar opinion, and the Liverpool Shipowners' Association pressed the matter on the attention of the Lords of the Admiralty, stating—"We are of opinion that if the depth of water into Waterford Harbour can be increased at a moderate expense so as to permit vessels of heavy draught to run in for shelter, it is very desirable that the work should be undertaken forthwith."

The Waterford Harbour Commissioners, though feeling that the work was of an Imperial character and one that should be carried out by the aid of the Public Exchequer, after having vainly endeavoured to get the assistance of the Treasury, in 1872 went for, and obtained an Act, to deepen this shoal, in the hopes of being able to obtain a loan, at a small rate of interest, for the purpose, which they were unable to procure.

The Harbour Commissioners employed Sir John Coode to make surveys, borings, and estimates, and it was on his plans that the Act of 1872 was obtained.

The result of Sir John Coode's investigations was to recommend a channel 600 feet in breadth, and 8,400 feet in length, giving 21 feet of water at low water ordinary spring tides. The borings discovered that the material would be easily

dredged, consisting chiefly of blue clay with incrustation of shells, and he was of the decided opinion that this cut once made, its tendency would be rather to deepen than to silt. His estimate for this work was £63,000, and with the improvements in dredging plant which have taken place since that period it may be confidently expected that at any rate this amount would not be exceeded.

With regard to the depositing of the dredgings there would not be any difficulty, the material either being taken to the open sea, or placed inside headlands on the shoal known as Ballinastraw flat.

As has already been stated, owing to want of assistance from the Treasury (in spite of the recommendations of the Select Committee of 1857, and the Royal Commission of 1859), the Harbour Commissioners have not been able to carry out this work, and so recently as last year the question again engaged the attention of a Select Committee appointed to inquire into the Harbour accommodation on the coasts of the United Kingdom.

A considerable number of competent witnesses were examined before this Committee, both technical and otherwise, and as a result the Committee unanimously passed the following resolution:—

“In Ireland the Commission of 1859 recommended two works of a similar character—viz., (1) at Carlingford, deepening the channel for a length of 3,700 feet, the breadth at bottom to be 600 feet, and the depth 21 feet at low water of spring tides, at a cost of £75,000—this work has been executed to this extent, that a channel 400 feet wide, having a depth of 18 feet as to 300 feet, and 14 feet as to the remaining width, has been dredged; the cost has, however, already been £80,000, advanced by the Loan Commissioners on the credit of the dues, which are not sufficient to pay the interest to the Commissioners, who are therefore unable to advance funds for



the completion of the work; (2) at Waterford, dredging the channel for a length of 8,000 feet, the breadth at bottom to be 600 feet, and the depth not less than 22 feet at low water of spring tides, at a cost of £50,000.

“ This work has not been executed. In 1873 the Harbour Commissioners obtained a provisional order enabling them to carry out this scheme, but were unable to satisfy the Public Works Loan Commissioners with regard to the security they were in a position to offer. Your Committee call attention to the opinion expressed by witnesses before them as to the great advantage certain to result from dredging the Duncannon shoal at Waterford. They desire to point out that these two works may be considered to no small extent of a national character, and therefore suggest that some help may be afforded from the public funds for the completion of the one and the execution of the other.”

Since then no steps have been taken by the Government to carry out this work, which, there is no doubt, would be of the greatest national importance to the shipping using St. George's Channel. In addition to the facilities offered by good holding ground, and safe anchorage, for any number of vessels of the largest class, there are soft mud banks at Ballyhack and behind Buttermilk Point, on which large vessels running in, with loss of anchors and chains, have been frequently beached, and in every case these vessels have been safely floated off again after having been provided with ground tackle.

Within the last quarter of a century 33 vessels have been lost in the neighbourhood of Waterford of over 400 tons burden, and there is little doubt that the greater number of these have been wrecked, not having been able to run for Waterford Harbour, owing to the want of sufficient depth of water over Duncannon shoal.

Harbours of refuge have always been deemed works of an

Imperial character, as it is not to be expected that the locality in which the harbour is situated should burden itself entirely beyond any benefit it might derive, to rescue ships not trading with the district. Large sums of money have been spent in breakwaters by Government in other situations of perhaps less importance geographically as harbours of refuge, but with regard to Waterford it appears as if the very smallness of the sum required makes the recommendation of Select Committee and the Royal Commission to be disregarded altogether.

With reference to the upper part of the river from Cheek Point to the city of Waterford, and which has been designated the "Port of Waterford," its regime only affects the direct trade coming into Waterford itself. The river has a varied character, but on the whole it compares most favourably with other rivers at the same distance from the open sea.

The range of spring tides at Duncannon, just inside Duncannon shoal, or what is commonly, though erroneously, called the bar, is 12 feet 6 inches, and that of neaps 7 feet 6 inches. At Waterford city the range of springs is 13 feet 6 inches, and that of neaps 8 feet. These figures represent only fair averages, the circumstances of heavy floods and certain winds altering the range of high and low water very perceptibly. The velocity of the tidal current varies considerably in different reaches of the river, both in ebb and flow, but when the current has no impediment it may be taken approximately at from 2 to 2½ miles per hour.

The first shoal that is met with after the junction of the Suir and the Barrow is at Cheek Point, and on this shoal there is only 13 feet of water at low water ordinary spring tides. This does not present a serious obstacle to the trade of the port, as vessels are not afraid of touching, the bottom being soft mud. The deepening of this shoal has frequently engaged the attention of the Harbour Commissioners, and is a work which the author is of opinion could be carried out at

a very reasonable cost, and the cut, when made, would be self-maintaining. Above Cheek Point for a distance of a mile and a half there is deep water averaging from 18 to 60 feet at low water ordinary springs—the area where the 18 feet is being very small indeed. Queen's Channel, lying to the north of Little Island, is now used by all vessels trading to the port. At the west end there is now 13 feet at low water ordinary springs, the depth increasing towards the lower end until it reaches 22 and 23 feet near the lighthouse. This channel was deepened by the Commissioners between the years 1860 and 1870. Before this work was executed there was only 6 feet at low water over some of the upper portion, and nearly all commerce went round the circuitous course to the south of Little Island, involving considerable danger in navigation both to steam and sailing vessels, and being a great impediment to the commerce of the city.

The Queen's Channel, as now executed, was carried out from the plans of Sir John Coode, and under his directions, at a cost of about £23,000. The upper length is cut partly through rock and partly through clay, of the very hardest description, involving considerable difficulties in the execution of the work. A guide bank was constructed from the dredged materials trending from the east point of Little Island in a direction parallel to the new channel, and this guide bank, pitched with stone on the channel face, serves to direct the tide in a proper course of ebb and flow to assist in maintaining the cut. At the end of the guide bank a lighthouse has been erected, which serves as a leading light for vessels coming up the river. At the west end of the channel there is a light on the Kilkenny side which serves as a leading light for the entrance of the channel, for vessels going down the river from Waterford; the channel itself being buoyed throughout its entire length.

The channel is 200 feet in width on the bottom, with side

slopes of 3 to 1. From the west end of this channel up to the quays there is continuous deep water, some places over 60 feet at low water of ordinary springs, and at mooring buoys opposite the centre of the town vessels drawing 24 feet of water lie afloat at all times of the tide.

With regard to the arrangements for berthing and discharging vessels, Waterford holds rather a peculiar position. The quays on the city side are about three-quarters of a mile in length, and the most of the trade is done from this side of the river; corn vessels lying at the deep water berths next the bridge, colliers occupying the space about the middle of the quays, the steamship companies having their berths at the lower end. Vessels and steamers do not come alongside the quays, but discharge on pontoons or hulks, which are always afloat, and are connected with the quays by gangways averaging about 60 feet in length and 10 feet in breadth, there being as a rule two gangways to each iron pontoon.

The quay walls are only founded at about half tide level, and the low water line varies from some 15 feet to 40 feet outside the external face of the quay.

On the north side above the wooden bridge the Waterford and Limerick and the Waterford and Central Ireland Railways have their goods station and terminus, and vessels carrying cargoes for transit over their lines come up to jetties, which have been erected by these companies some years since. The Waterford and Limerick Railway have also within the last three years constructed a wharf on the north side for a length of 1,560 feet, and made a branch line so as to have railway connection with this wharf, thus avoiding the inconvenience of vessels having to come through bridge. There are also two or three pontoons where large corn vessels occasionally discharge their cargoes into stores which are at the water's edge.

In a valuable history of the County and City of Waterford, written by Mr. Charles Smith in 1746, the following descrip-

tion of Waterford, as regards its quay and shipping facilities, may be interesting:—

“The kay of this city, which is above half a mile in length, and of a considerable breadth, is not inferior to, but rather exceeds, the most celebrated of Europe. To it the largest trading vessels may conveniently come up both to load and unload, and at a small distance opposite to it may lie constantly afloat. The Exchange, Custom House, and other publick buildings, besides the houses of the merchants and citizens ranged alongside the kay, are no small addition to its beauty; which, together with a number of shipping, afford an agreeable prospect. The whole is fronted with hewn stone, well paved, and in some places is 40 feet broad. To it are built 5 moles, or peers, which stretch forward into the river; at the peer-heads ships of 500 tons may load and unload and lie afloat.

“In the road before the kay the river is between 4 and 5 fathoms deep at low water, where 60 sail of ships may ride conveniently clear of each other in clean ground. The tide rises and falls here 3 fathoms, the current setting east and west. At the west end is a convenient place for graving and calking vessels, called from thence the Graving Bank.

“But a much more commodious place is the dry dock, which lies a little below to the east, and was built for this purpose by the late Ambrose Congreve, Esq. This dock is properly fitted with flood-gates, and is very convenient for the repairing and fitting out vessels. It is 160 feet long, 48 feet broad, and 15 feet deep. The flood-gate entrance is 28 feet in the clear, receives ships of large burden, and is kept in good order for that purpose. For the conveniency of vessels taking in water, conduits and pipes are placed on the kay, so, in this respect, strangers cannot be at a loss.”

It will be observed that 140 years ago Waterford possessed both a graving bank and dry dock, and the contrast, as regards the present, is in favour of the past.

As far as the dredging of the port is concerned, comparing it with other ports of about the same trade, a small number of tons annually raised is sufficient to keep the port clear for ordinary purposes; 120,000 tons in one year may be taken as the maximum which has sufficed for the past number of years, the average annual number being under this. The removal of the mud has been always a source of difficulty and expense. The practice has been, and is, to convey the dredged material in barges carrying about 40 tons each to such places either up or down the river as may be convenient for putting the stuff on to the bank above high water mark; the owners of land, in many instances, being glad to have the opportunity of raising the low-lying portions by this (to them) cheap method. The writer has always been of opinion that this is not a good system. The boats are manned by four men, and the material is carried out by means of hand barrows, the men walking on long planks stretched from the boat to the shore. The temptation, of course, is very great to take as little trouble as possible, and not to put the stuff sufficiently far inland, so as to be well out of the reach of high tides. It is also very doubtful whether a lonely part of the river, or the darkness, is not often taken advantage of for the purpose of heaving some of their cargo overboard, and thus saving the labour of barrowing it ashore.

There are two men in the employment of the Commissioners told off for the purpose of watching that the boats discharge properly on land above high water mark; but it is quite impossible that these two men, let them be ever so honest, or willing, can have complete supervision over from ten to fifteen boats, discharging at different places in the river. The price paid for removal of mud is 7½d. per ton to what are termed outside boats, and 6d. per ton to Commissioners' boats. The outside boats are owned and manned by people who are responsible for all charges of repairs to boats,

crews, &c. ; in fact, the Commissioners only charter them for each load. The inside boats, receiving 6d., are owned by the Commissioners, and lent out to crews; all repairs to these boats being done without any expense to the crew.

The Harbour Board at different times have considered the question of adopting some cheaper and more satisfactory method of removing the mud, but the requisite capital expenditure to do this has always proved a deterrent. The solution of the difficulty seems to point towards taking the dredgings to sea, but the very smallness of the number of tons raised annually makes the expense per ton larger, when the interest on the capital required for purchasing new plant is taken into account.

The writer is of the opinion that much could be done by judicious works to materially lessen the present deposit of silt in the river; and in 1883, Mr. Mandeville, his assistant, made a careful series of float experiments on the ebb tides, extending over a period of 30 days, for the purpose of ascertaining the set of the currents, and procuring definite information to guide him in coming to a conclusion.

The deposit of silt in the city reach of the river has been *nil* as far as the centre half of the river is concerned for certainly the past 40 years. The Admiralty chart of 1848 shows the same depths in this portion of the river as the writer found quite recently, and, as far as he can learn, no dredging operations have taken place there.

Waterford City is on the wrong side of the river as regards the lineation of its quays. If the quays had been constructed on a gentle concave curve, following the natural outline of the lower part of the city reach (on the opposite side to which they are at present), it is most probable that the dredging requisite to maintain the proper depths would have been very small indeed. Cities are, however, not easily moved, and the improvement of Waterford Port, in its present position,

is a more practicable problem than to discuss what might have been if the quays had been laid out differently and in another place. By referring to the map of Waterford it will be seen that about  $\frac{1}{4}$  mile above the bridge the river narrows considerably—a cliff, called Bilberry Rock, projecting out on the S.W. bank, and this projection plays an important part in the direction of the ebb tide. The tide sets in strongly towards this point, and is there broken up in eddies and back water, being also somewhat deflected towards the opposite side in its downward flow. The berths on the city side above bridge (extending only for about 500 feet) never require dredging, and the upper corn berths below bridge do not require dredging as frequently as the collier and steam berths. The writer made a report to the Commissioners on the subject, and advised that the river at Bilberry Rock should be widened by cutting off the projection; that the bight above should be narrowed so as to form a gentle concave curve, leading the ebb tide along past Bilberry, and delivering it so that its power should be exerted directly along the line of quays.

The writer is also of opinion that the quays should be extended to deep water, thus gaining valuable quay space, as well as tending towards the reduction of dredging.

The present system of discharging vessels alongside pontoons has many advocates among the people most interested in the trade of the port, and, therefore, a proposal for deep water quays is not looked on with general favour. As regards the cattle traffic, there is no doubt that there are many advantages—the steamer always lies alongside the hulk at the same level as regards her decks and the hulk (except as regards her floatation lines due to cargo), and at low water spring tides the cattle can be shipped with great rapidity in large numbers, owing to the easy incline of the long stages (60 feet in length) from the quay to the hulk; and their width (10 feet) being much greater than the usual cattle stages between



quay and vessel, they allow a large amount to pass on board at the same time.

As regards the loading and unloading of goods, the case is quite different. Every ton of stuff, whether export or import, has to be trucked, or rolled by hand, at least 80 feet, instead of being put out on to the quay direct from the ship's hold. At low water this becomes a very serious matter, the incline of the stages being approximately 1 in 12, thus involving a considerable amount of labour in discharging a cargo where dispatch is an object. One of the steamship companies whose chief trade is in goods, considered the floating hulks and stages a great cause of delay in the dispatch of their steamers, and they memorialised the Harbour Commissioners to erect a timber jetty for one of their berths, which the author has done. The jetty is 150 feet long in the head, and 25 feet in width; its face is in a line with the outside range of the pontoons, and connected to the quay by two fixed gangways of 13 feet 6 inches wide each; all being on quay level.

The result has been most satisfactory; the boats get cleared of their cargoes in nearly half the time they took alongside the floating pontoons, although the 80 feet of portage from the vessels' side to quay has not been obviated. The writer is of the opinion that, taking everything into consideration, the deep water quays would be found to answer best for all purposes of trade. The range of tide at Waterford being only 13 feet 6 inches springs, and 8 feet neaps, arrangements could be easily devised that for the berths where the chief cattle traffic is carried on, sloping recesses could be constructed so as to have wide gangways with not too steep an incline, in order that when shipments were made at low water spring tides (which would only be occasionally) the cattle could be shipped with as much facility as at present.

There is one serious drawback to Waterford as a port, and that is, it is wanting in dry dock accommodation. The dock

mentioned in Mr. Smith's history is not now in existence, and there is no facility for repairing or examining ships. The Commissioners obtained a Dry Dock Act in 1868 and bought land for the purpose, Sir John Coode preparing the contract plans for the work, and on these tenders were invited in 1879, but the Commissioners did not consider that the undertaking would be a remunerative one, and the project was allowed to lapse.

A table is appended showing the tonnage of the port for a number of years with the gross revenue. It will be observed that in comparison with the tonnage the receipts are small when viewed relatively to other ports, taking receipts per ton; this is largely owing to the fact that there are not any town dues, and that generally the dues are less than is usual.

Year	Revenue			Tonnage	Cost of Dredging and Removal of Mud			Tons removed
	£	s.	d.		£	s.	d.	
1860	9,942	15	10	336,871	648	16	10	17,007
1861	10,850	3	0	371,948	374	9	5	8,209
1862	11,071	13	10	389,533	856	9	11	10,168
1863	10,100	7	0	384,336	2,138	8	10	52,030
1864	9,429	14	7	397,287	4,086	8	4	120,439
1865	8,008	5	3	365,036	1,796	13	9	42,384
1866	9,667	13	6	415,002	74	15	0	2,990
1867	10,145	10	3	450,445	407	9	5	6,965
1868	10,368	19	0	445,921	222	9	5	5,940
1869	10,071	1	2	444,733	294	18	9	4,200
1870	12,173	7	11	469,650	1,731	15	7	34,731
1871	13,884	8	10	448,323	2,175	4	7	70,375
1872	13,529	0	0	439,419	1,464	7	5	37,596
1873	14,722	3	9	465,420	1,372	12	5	29,935
1874	13,995	16	1	433,700	2,538	1	0	43,002
1875	16,504	14	5	488,490	2,399	16	2	49,854
1876	16,976	15	0	519,327	2,568	6	9	66,058
1877	18,049	14	8	603,623	2,790	18	10	67,523
1878	19,751	10	4	615,137	3,277	10	8	72,473
1879	20,070	18	5	649,606	3,622	18	4	55,767
1880	18,318	16	7	621,155	5,584	16	5	105,337
1881	18,765	12	8	617,694	3,747	4	7	82,800
1882	15,340	6	3	545,036	2,445	0	5	45,288
1883	16,533	11	4	527,617	1,421	6	3	10,584
1884	17,284	5	2	554,507	2,750	16	5	54,730
1885	14,313	15	6	523,851	2,677	8	6	39,232
<b>Totals</b>	<b>359,871</b>	<b>0</b>	<b>4</b>	<b>12,523,667</b>	<b>53,649</b>	<b>4</b>	<b>0</b>	<b>1,135,667</b>

Average number of tons removed per year . . . . . 43,680

Average cost per ton . . . . . 11-33d.

[3rd February, 1886.]

J. A. F. ASPINALL, President,  
in the Chair.

The following Candidate was balloted for and duly elected:—

JOSEPH P. MURPHY, as Associate.

TECHNICAL EDUCATION FOR ARTISANS.

By W. R. MAGUIRE, Associate.

THE President of this Institution of Civil Engineers invited the Members and Associates, in his Inaugural Address this session, to contribute papers on technical education, and on various other subjects, which his experience enabled him to suggest; and as the author has been encouraged also by further assurances that a paper would be favourably received and leniently criticised, coming from an Associate recently received into the outer court of the Institution, he has ventured to select that subject which seemed at once the most important and the most appropriate to the time and place.

The present want of technical education in Ireland—a want which we may hope soon to see taking active shape as a demand—has been created within the last century, chiefly by the brains and hands of our Civil Engineers; to them may be traced the amazing progress of steam-power development on land and sea, accelerating the growth and extension of manufactures, engineering, agriculture, and commerce, throughout the world, almost annihilating time and space, so that raw material and produce, coal and iron, as well as finished goods, are transported from place to place with a facility unrealized, and hardly dreamed of fifty years ago; opening

up new occupations and new careers not alone to our artisans, but also to those of foreign nations, who are now competing with us everywhere ; we have taught to other nations what great things energy can accomplish, and "it has gone hard, but they have bettered our instruction," by setting the power of technical knowledge in the scale against our advantages of mineral wealth.

It appears reasonable and appropriate, therefore, that those who have created this urgent need of a special kind of education for our artisans, should help to consider the best means and indicate the best methods for supplying this want, and for providing a special education, having direct reference to the new careers, occupations, and future life-work of the population.

Technical training has always been provided for the lawyer, in Latin and logic ; for the statesman, in history and elocution ; for the doctor, in medicine and anatomy ; for the clergyman, in theology, Hebrew, and Greek ; but it is the purpose of this paper to consider the best form of technical training for artisans, mechanics, and designers, which, in addition to fitting them and their children for the occupations they are to follow, shall also afford a means of enabling the brightest and most industrious among the students to advance through systems of higher training to higher positions, as foremen and managers of works.

Real technical education is that which applies the principles of the natural sciences to the practice of the mechanical arts and industries connected directly with the future careers and occupations of the students. Ireland may be justly proud of the distinguished workingmen she has given to the world, as doctors, lawyers, and soldiers, and it will be instructive to inquire why it is that in these professions particularly the transcendent abilities of her sons have been so universally marked.

Is it not just because that for these very professions technical education has been fully provided? The medical student finds lectures, laboratories, and workshops, with the highest class of teaching possible, in the medical schools and colleges of Dublin. The apprentice of the lawyer has his technical school and college, his debating society and club, and his practice in the office and in the courts. The soldier is trained and drilled; he has his distinct technical education in the barrack, in the camp, and in the military schools and colleges.

In each profession the brain, hand, eye, and tongue are educated with special reference to the particular career adopted, and thus success has been attained, and Irishmen have risen, as doctors, lawyers, and soldiers, to the highest positions the world has had to offer them; but it has been overlooked that their successes were largely due to the fact that their technical education specially fitted them for their work in life.

All education should be, in one sense, technical—that is, it should be devised and carried out with the sole object of preparing the individual student, in the best possible manner, for his real life-work. Therefore, it would appear that the half classical education of the grammar schools and the literary education of the National schools, which we have depended upon so long, are not the best adapted for young artisans, or foremen, or manufacturers, whose school time must necessarily be more condensed than that of persons who intend to follow the learned professions or who can afford to live a life of ease.

In olden times the system of apprenticeship provided a sufficient technical education for young artisans; then each master followed his own limited trade exclusively, and being invariably a practically experienced master, he was able and willing to devote time and care to the technical craft instruction of his apprentice—every workshop was a school.

In the present day, although the same legal form of indenture

is signed in the act and deed of an apprenticeship covenant, binding the master, both legally and morally, to provide sufficient technical teaching for his apprentice, how seldom is the obligation realised or its fulfilment even expected.

The universality of this neglect of duty, however, does not relieve the master from his full responsibility ; he has, by the deed of apprenticeship, incurred a debt to the public as well as to his apprentice, and that debt should be paid. If the high pressure speed of the present period prevents the master from sparing sufficient time for the due instruction of his pupil, he becomes morally bound to provide the necessary training in some other way and by some other teachers.

The apprentice may learn a limited part of his trade during his term of service, but he rarely learns enough, and as this workshop training grows more meagre and more hurried year by year, it must be supplemented by other training such as the technical school alone can supply.

Workmen and apprentices both need a knowledge of the theory or science connected with their practice ; they may obtain special information in the workshop, they may learn how to make an article to fit a particular place, and they can repeat that lesson as a parrot can by rote, but if they are placed in a position where they are required to alter the construction to suit other circumstances, they are lost and puzzled and probably fail. If they had the foundation to work upon which scientific knowledge affords, the new pattern would come as easy to them as the old one. This thorough knowledge is just as much better than superficial knowledge as the understanding of language is better than a parrot's senseless talk.

A workshop trick, though useful under one sole condition, becomes as useless under fresh conditions as a straight tip to a greenhorn on a racecourse, when the horse he was advised to back is scratched, and he has no technical turf training to enable

him to select another to supply the vacant place; but, unfortunately, workmen will usually appreciate a teacher better who gives them these straight tips than one who, with conscientious soundness of teaching, tries to impart solid and enduring knowledge.

One thing seems certain that if the commercial prosperity of our country is to be permanently secured, the thorough education of the workmen must be permanently secured also. England held her place for many years as mistress of the world of manufactures by virtue of the wealth of her resources, her coal, her iron, and her energy; but other nations have made up their deficiencies by a quiet, steady attention to technical education, while England, resting in the consciousness of her material strength alone, has slumbered and slept. We have to remember that although our neighbours on the Continent do not possess the real grit of the Saxon or the Celt, and that by waking up in time we may still keep ahead of them, yet that in America we are met by competitors of our own kith and kin, and that it is in the competition from across the broad Atlantic we may most fear for the final results of our struggle for pre-eminence in commerce and manufacture.

The State, as representing the community, should provide technical schools of all classes suited to the requirements of the artisans near to their houses. Artisans cannot afford, as rich men may, to select schools for their children to suit their own ideas by paying for the kind of education they desire; yet, the nation's prosperity depends on the proper and complete education of the poor far more than on the education of the rich, and this will be found to be the case more and more every year.

The root of all technical education lies in the primary education of the people; and until we have a nation whose young people are thoroughly trained in elementary science and art, our technical teachers can have no fair scope for their

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work. Our national primary education should be rendered compulsory as well as efficient, so that every capable boy and girl should be turned out of school, at the age of 14, with a sound foundation knowledge of reading, writing, arithmetic, rudimentary drawing, elementary practical geometry, and the use of common tools. Such primary education, though theoretically desirable, is not yet to be found in Ireland in actual practice; and until this efficient and universal training of children is made an accomplished fact, we cannot hope to compete with those German workmen who, leaving their primary schools for the workshop, at the age of 13 or 14, well trained, are yet compelled to continue their education at evening classes until they are 16 years of age. When a lad leaves school for the workshop, at 13 or 14, he is in the position of a child sent out on a message from a quiet room into a busy thoroughfare—often the message and directions are forgotten and wiped out in the noise and jostling of the crowd; the lad will probably forget the lessons he has laboriously acquired, unless some suitable teaching is provided, during his apprenticeship, to sustain his interest in his studies and to lead him on. Where evening technical classes are opened to such lads this want is supplied. At first such classes must begin very low down, by teaching very elementary lessons, until the time comes when the general system of national primary education shall be adjusted and raised, to provide the elementary knowledge which all lads of 14 should possess.

The employers and masters should be induced to take a special interest in these evening classes. They might give preference to those artisans who, by the regularity of their attendance at such classes, show their willingness to take advantage of the teaching provided.

Employers can only interfere advantageously with their workpeople, after working hours, by delicate and judicious management, and by encouragement rather than by compul-



sion, not punishing any who see fit to disregard the educational advantages offered, while rewarding those industrious apprentices and journeymen who are wise enough to perceive and use the benefits placed within their grasp.

The cordial and judicious co-operation of parents and employers will be necessary at first to insure the success of the classes. It would be unreasonable to expect the artisans and apprentices, who have been accustomed to spend their evenings in idleness or amusement, all at once to be quite willing to devote their spare time to the acquirement of knowledge ; but the love of study and improvement will eventually take possession of the lads' minds, and they will then appreciate the advantages of knowledge in the battle of life.

There can be little doubt that the majority of inventions spring from the minds of artisans—they are in hourly contact with their tools, machines, and materials ; they see and handle the details, and they suffer from defects, until at last a vague idea occurs to them, almost of necessity, how to improve or remedy ; but the want of technical education prevents the workman from profiting by his observations, which are, perhaps, communicated to the foreman, overseer, or employer, who, if he possesses the necessary education, along with the aptitude, to grasp the new suggestion, generally profits by the experience of the artisan.

Think of the marvellous improvements in machines and processes first suggested by workingmen, and multiply that thought by what they might have been if the technical education, now established in London and abroad, and which we hope to see established in Ireland, had been available during the last fifty years ; we should most certainly be a more prosperous and comfortable people, and therefore more contented, than we are.

On the Continent the numerous art and technical schools are universally stimulating the growth and improving the tone

of manufacturing industries. The States and municipalities are impressed with the belief that they can meet our competition, and overcome our material advantages, by training their workmen in taste and skill, and by giving their foremen and managers of works such scientific instruction as shall enable them to apply every principle and law of nature to the benefit and furtherance of their several handicrafts and manufactures. They strain every muscle in this competition; everywhere they find their industries prosper, in proportion as they keep up the practical efficiency of their schools.

Germany, thirty years ago, was utterly unable to compete with England. The Germans at that time induced many practical English Engineers to settle in Germany. These men, as Directors of their Engineering Works, consolidated and extended the manufactures of Germany, watching carefully and importing all new English machinery and tools, following English methods step by step, and, above all, steadily working at the scientific technical education, the scientific and the practical side by side, which the English continued to pass by and neglect, till Germany reached a point in her career where she has little to learn from England in any branch of manufacture.

Now Englishmen are no longer induced to go to Germany; they are no longer at the head of German workshops. Germany has educated her own manufacturers, managers, and foremen. Practical men are no longer wanted from England; but the tide has turned, and England now seeks scientific men from Germany to help her to retain the industries she has jeopardized, or to recover those she has lost.

When we can educate our workmen in applied science and art as the German artisans are educated, also teaching them manually and practically in the workshop and in the school, we can hold our own against the world.

The military system of Germany, which demands and

absorbs the three years of life best suited for handicraft training, is the curse of the German artisans, and hangs as a clog on their progress; but though we are free from this military despotism, we are weighted in another way—our manufacturers have to deplore the effects of our drinking customs on our workmen, and if we are beaten in the National race for supremacy, strong drink will be the weight that drags us down. Technical education will have a strong tendency to diminish this evil.

In all gratuitous educational systems provided by or assisted by the State, it is right to remember that handicraft training should be limited so as not to give the students gratuitously complete instruction in any particular trade, but to aim for and stop at conferring a certain amount of readiness and aptitude in the use of tools, and generally developing faculties of observation.

Where the State provides funds out of the general taxes, and therewith gratuitously gives a full trade to any class of the community, the other tax-paying classes may fairly, though selfishly, object that they should not be compelled to bear a burden for the benefit of others.

If parents paying small taxes could have their children educated and taught trades or handicrafts free of cost by the State, why should not other parents paying higher taxes have their children educated as lawyers, doctors, or clergymen free of cost also.

The State, in the general interest of the community, can only be called on fairly to furnish the rising generation gratuitously with so much technical and general knowledge, and in such a way that it can be applied to trades and manufactures generally.

It will be found proper, therefore, that while the State may aid and assist technical schools largely as being for the general good, yet that they are bound in the interests of the community,

to require that the particular individuals and trades particularly benefited shall directly contribute to the cost.

In order to take the first step towards improvement we require to know how far behind the rest of the world we are lagging in technical education, so that it appears necessary, though tedious, to consider the systems adopted by foreign countries for primary and secondary education as a preparation for or part of technical training, as revealed by the investigations of the Royal Commissioners of Technical Education.

#### CONTINENTAL PRIMARY SCHOOLS.

In France primary education is made compulsory; higher elementary, including technical instruction, is freely provided in many large towns, and education grants are rapidly increasing for the establishment of such schools.

Secondary education is provided still rather on the old classical lines, with mathematical instruction towards the end of the term for lad<sup>s</sup> intending to enter technical colleges.

French primary schools far excel ours as a preparation for technical training, owing to the special attention given to freehand drawing from carefully devised models, geometrical drawing, and the use of tools. Secondary schools excel ours in the same way by devoting greater attention to mathematics.

In Switzerland, taking Zurich as a sample, primary and secondary education is provided free. All children between the ages of 6 and 14 must attend school; they *must* remain at the primary school until they reach 12 years of age, and then must either attend the secondary school for 2 years, or, if they leave the primary school at 12 for work, they must attend a supplemental school held on 2 half-days each week for 4 years.

It is a wonderful record that 97·5 per cent. of Swiss children attend the public primary schools, and that the thirst for education among the people is extreme. It is intended to pass a

law—if it be not already passed—to compel attendance at the primary school to the age of 14. No child can enter a factory until the end of the 14th year. £43,000, = about £66 per head, was expended in building a primary school at Zurich, in which all the children are taught one foreign language, drawing and natural history, and in the higher classes, chemistry and physics. A school museum of simple chemical and physical apparatus, relief maps, useful minerals, botanical models, &c., is attached, in which many of the specimens are prepared and arranged by the teachers. The attendance is remarkably regular, and the children bright, clean, and tidy in appearance.

There are also higher schools for boys, classical schools and trade schools which prepare for the colleges or for direct entrance to trade. Boys enter the classical school, after examination, at 12, and leave at 18 or 19, to pass without further tests to the university or polytechnic. Boys enter the trade school at 14, and leave at  $17\frac{1}{2}$  or 18. The first class is preparatory, dividing in 2nd class into technical and commercial sections—the technical section dividing during 3rd and 4th year into mathematical and natural science sections; the commercial section ending with the 3rd year.

In Zurich the classical and trade school is located in one building, and includes 500 pupils and 44 masters.

In the trade school is a chemical laboratory, where the boys have six hours simple practical work per week. Lectures are given on physics with excellent experiments. Six hours per week is devoted to drawing.

The industrial condition of Switzerland is immensely benefited by these schools.

Girls' schools similar to the trade school for boys are provided, and are attended by girls from 12 to 16. Social distinctions are not recognised. Male teachers are largely employed in these schools.

The cost of education in the Canton of Zurich amounts to nearly one-third of the whole expenses of the Canton, and is always cheerfully contributed.

The influence of technical education on the prosperity of Zurich may be observed clearly by everyone having an opportunity of spending a day or two in the town.

In Germany the system of primary education varies in different States, but is compulsory. The children of all classes enter the public schools at 6 and remain till 14, except those who enter preparatory schools with a view to receive their education in higher elementary schools.

There are three kinds of secondary schools in Germany—the gymnasium or classical schools proper; the real gymnasium, in which Latin (but not Greek) is taught, with science and mathematics; the Ober real schools, in which only modern languages are taught, and special attention is given to drawing and science, the complete course occupying 10 years in all these schools. The Unter real schools are of a lower grade than those named, and are merely higher elementary schools.

Pupils from the gymnasium are entitled to enter any faculty of the university and the polytechnic. Pupils from the second grade, or real gymnasium, can only enter the philosophical faculty of the university and the polytechnic. Pupils from the third grade, or Ober real schools, can only enter the polytechnic. These schools are all supported by public funds, and as private secondary schools are unknown in Germany it follows that a systematic first-class education is almost forced upon the children of the middle classes. In Saxony and in some other States children whose education is insufficient at the age of 14, when they go to business, are obliged to attend continuation evening schools for two years longer.

In Austria and Holland the primary, middle, and high schools resemble those of Germany, and need no special comment.

The total cost of education in Holland in 1883, with 4 millions population, was  $1\frac{1}{2}$  millions, of which the central Government provide £375,000.

In Belgium attendance at school is not compulsory, but each Commune is bound to provide, at least, one public school. Parents can demand gratuitous instruction for their children.

The clergy do not approve of the Government schools in Belgium, and, consequently, clerical secondary and primary schools are conducted by the clergy, side by side with the Government schools. Sixty per cent. of children at school age attend Government schools, 25 per cent. clerical schools, and 15 per cent. do not attend school at all. Any person is free to establish a school of any type or grade without any control. Government Inspectors have no right to enter clerical or private schools. Thirty per cent. of the adults of Belgium can neither read nor write at the age of conscription; the proportion of illiterate varies in different provinces. There are no laws to prevent young children being employed in factories. Higher education is carried on in four universities. No polytechnic schools are established in Belgium.

In Italy primary education is gratuitous, and is compulsory by law, though in some parts of the country the law is not carried out. Parents may evade the law by certifying that they are giving necessary instruction at home. The primary education, commencing in the infant school to the elementary school, spreads over five years. On leaving the elementary school children pass to the classical school or technical school, according as they are intended for the university, for a commercial or industrial career. Many private schools, also, are established under the direction of the clergy.

Efficient primary education is the very root of all technical instruction. In this country the promoters of technical education and the managers of technical schools will experience at

the beginning of their work a want of properly trained material to build upon. Speaking generally, from observation of the lower, middle, and working classes in Ireland, the quality of education seems to be very defective indeed. Take a set of workmen, apprentices, and lads in any workshop or factory, and examine them with a view to ascertain what amount of primary instruction they have practically received in a retentive form at school, and you will find a poor foundation indeed on which to build a superstructure of technical instruction. Reading and writing may have been attained, but arithmetic is shaky, decimals and vulgar fractions a name only. Drawing is quite unknown, geometry or elementary science unheard of.

For some years, technical education systems must provide and commence with an elementary grade, in the hope that, when National primary school teachers see what standard is required in pupils seeking technical instruction, they will regulate their training accordingly, and so present an abundant supply of eager and youthful material for the technical instruction so much needed in this country.

We have thus far explained the systems of primary education adopted by other countries to show how very far we are left behind even at the outset of technical education.

#### EVENING TECHNICAL SCHOOLS.

The system of evening instruction in France is arranged for men and women.

The State provides instruction at the Conservatoire National des Arts et Métiers, and at the École des Beaux Arts. The municipalities, various associations, and private individuals, provide lectures and classes in many schools through the city and country.

The Conservatoire is open free to the public, and seeks to encourage scientific tastes by free popular courses of theo-



retical and technical instruction, by its splendid museum of models, &c., and by its library.

The subjects of the various courses include:—Applied Geometry, Descriptive Geometry, Applied Mechanics, Building Construction, Applied Physics, Applied Chemistry, Industrial Chemistry, Agricultural Chemistry, Spinning and Weaving, Rural Economy, Industrial Economy, Political Economy, Commercial Law, Agriculture.

Two great societies, the Polytechnic and Philotechnic Associations, possess complete organisation for elementary instruction by lectures and courses in Paris and through the provinces. Over 150 professors are employed at this work in teaching arithmetic, geometry, physics, chemistry, machine construction, drawing, book-keeping, geography, natural history, astronomy, hygiene, and modern languages.

In Amiens, Rheims, Lyons, and other towns in France, independent societies are formed for science and technical teaching.

Special evening art classes are everywhere held in France for the instruction of artisans, and they exert vast influence on art industries.

There are over 100 evening art classes in Paris alone, with 5,500 students under instruction. Of these, 65 classes are supported by the municipality of Paris. The *École National des Arts Decoratifs* was founded in 1765 for teaching artisans. About 800 students are admitted by competition, and many of the best artists and designers in France owe their success to the early training there received.

The Paris Municipal School of Art, Rue Turbigo, gives instruction to 300 pupils every evening. Here modelling and drawing from life is taught to stonemasons, carvers, joiners, silversmiths, jewellers, and to representatives from all the trades of Paris. There are always many more desirous of attending than can be accommodated.

There are similar schools in nearly every French provincial town in Lyons, Toulouse, Limoges, Rheims, Amiens, Lille, Roubaix, &c.

In Switzerland the continuation schools furnish evening instruction for artisans.

In Germany the evening schools take an important position in the training of artisans, as special care is taken to render the teaching suitable for young workmen. Attendance at evening continuation schools in some parts of Germany is compulsory, and in addition to the State schools are others provided by associations of workmen for evening instruction in literature, drawing, and elementary science.

The Berlin Artisans' Society in the capital, and the German Association for the Diffusion of Popular Education possess branches in all parts of Germany where lectures are delivered. In the former society there are over 2,000 members. They meet for lectures, conferences, and technical instruction, as well as for amusements, gymnastics, and singing classes, in which all members, together with their families, can participate. There are 148 carpenters, 95 locksmiths, 82 masons, 75 bookbinders, and many other trades enrolled. There is a building trades' school connected with the society for winter work, open from 31st October to 29th March. There are evening schools for teaching technical drawing in Berlin suited for artisans, and there are Sunday classes established also.

There does not appear to be any system of evening science classes in Germany similar to those in France or Belgium. The want of this instruction is much felt by Germans, and evening science schools are likely to be soon established.

In Austria evening instruction for artisans is chiefly provided by numerous trade societies, in order to give instruction for apprentices or improvers in the scientific branches of the trades. A stipulation is frequently made by masters that the apprentices shall attend these schools.

The turners' school for apprentices has 170 pupils; it is supported by the turners' society, who compel their apprentices by indenture to attend. It is usual after leaving the primary school at 14, for lads to go to practical work for a year, and then to enter the classes. During first year teaching is theoretical in arithmetic, elementary physics, book-keeping, and technology of the trade raw materials. During second and third year practical modelling, carving, and turning is taught. The school is provided with lathes; one lathe has rows of raised benches round it for the pupils, to enable them to watch the demonstration of the practical turner. The value of this instruction is very great, as in the workshops lads are constantly occupied with one kind of work, and would never learn their entire trade. The watchmakers' school and the jewellers school are on a similar system.

In Belgium evening instruction is well provided. There are three evening schools in Brussels for artisans—Molenbeek St. Jean; St. Josse-ten-Noode; Ixelles. In these the classrooms and appliances are excellent. The system of teaching drawing is peculiar; black-boards surround the class-room on which the boys draw in chalk; when proficient, they are taught to draw with charcoal on paper. They are led from outline drawing to shading, and in the third year draw from life. The quality of this teaching is suited well to artisans, producing rapid and bold work without great finish. The pupils acquire a sufficient power for trade drawings in much shorter time than under the English system.

In Holland similar evening art schools exist. Unlike France and Belgium, fees are charged, it being found that pupils place greater value on the education they pay for, and, as a fact, the schools are overcrowded.

In Italy evening classes for artisans are held in most of the towns. Taking Udine, a small manufacturing town, as an example, evening schools are held for elementary mathematics,

mechanics, and technology, as well as for drawing and modelling—350 male and 110 female students attend.

#### APPRENTICESHIP SCHOOLS.

Apprenticeship schools are largely adopted on the Continent, superseding apprenticeship wholly or partially. They do not seem, however, to have received approval in England with those who have most closely studied technical education.

In France we may take the apprenticeship school of the Rue Tournefort, Paris. Here children from six to ten years old are received and taught, getting three hourly lessons per week in manual work. Boys of ten and eleven are taught drawing, modelling, carving, joiner's work, smith's and fitter's work generally, but in their twelfth year the instruction is specially directed to the trade the boy decides to follow. School hours are from eight to six, and in the highest class eighteen hours a week is given to manual work.

The school of La Villette, Paris, is a municipal apprenticeship school for workers in wood and iron. The instruction is free, including a literary and scientific education in continuation of the primary school, and also a special technical training by instruction in tools, materials, and workshop processes, and by practical manual work in the workshops. Visits are paid by the pupils to factories in Paris, and written accounts of the processes seen there are required from the pupils. Many of the boys become engine-fitters and pattern-makers, and are said to earn 2s. 6d. to 5s. a day on leaving the school.

In Switzerland apprenticeship schools do not seem to exist.

In Germany the technical school system was established by Dr. Von Steinbeis, as a consequence of the observations he made at the Exhibition of 1851. They have spread over Germany, North and South.

One of the best is the Fach-schule of Iserlohn, in Westphalia, in a great coal and iron district, whercin industrial art

adapted to metalwork is combined with handicraft teaching. The pupils are trained during three years as designers, modellers, wood carvers, moulders, founders, turners, chasers, engravers, gilders, and etchers. Each pupil states at entrance what branch of manufacture he desires to excel in, and the teaching is made special.

Remscheid trade school, 18 miles from Düsseldorf, is established for instruction of apprentices in construction of edge tools and other implements and hardware made in that district. The town was till recently a small village, but now competes with Sheffield and Birmingham. The trade is carried on in small shops extending for miles into the country. In the school workshops, pupils are taught drawing in connection with ironwork, as well as the practical handicraft of the iron trade as it is carried on in small factories, so that, on leaving the school, they may at once earn their living. The fees paid by students amount to £4 a year.

A pottery trade school at Höhé, about six miles from Coblenz, was established by the Prussian Government to assist a small local industry, and, although it has been but a short time in existence, the instruction and practice is producing marked improvement in the local manufacture.

The effect of the teaching of drawing in primary schools on German pottery is very marked. Many rough designs on cheap earthenware are drawn and painted by mere lads just from the schools and at small wages, and are being imported largely into England. These common goods can be made much more cheaply than in England, owing to the artistic skill of the young apprentices.

There are many trade and industrial schools on similar lines and for similar purposes in Cologne, the Black Forest, Bavaria, Thuringia, all of which are adding to the commerce and prosperity of Germany.

In Austria the Government are largely aiding apprentice-

ship schools. There are over 90 for teaching various industries now established—schools for textile manufactures, for wood and stone work, for pottery and glass work, for metal work, for toys, for carpenters, for mechanics.

In Vienna the joiners' school for winter teaching is organised and controlled by the joiners' trade society, but receives a grant of £500 a year from Government. The teaching spreads over three and a half years, when the students are supposed to leave with a practical knowledge of the trade.

At Riva, in the Tyrol, is a wood-working school, where a general education is combined with special theoretical and practical instruction in modelling and carving wood.

It is stated that new industries have been created by such schools as these. Arco, near the Lake of Garda, in the Tyrol, being an instance where olive wood was once only used for fuel, is now the centre of a flourishing trade started by a technical school.

These *Fach-schulen* have been established in Austria to remedy acknowledged defects in the apprenticeship system, and have served, it is stated, to develop industry to a great extent in Austria.

In Belgium the apprenticeship schools are designed to give the workman a knowledge of scientific principles, which he cannot attain in the workshop, to develop his intelligence, to lead him higher than mere routine, and to enable him to contribute something towards increased production for his own and his nation's advantage. The hours of school work are from 7 to 9 30 every evening, and for three hours on Sunday morning. The schools are free, supported by Government and municipal grants.

About forty of these schools are so supported. The instruction varies to suit requirements of each locality. General courses comprise drawing, arithmetic, geometry, technology, physics, chemistry, mechanics, hygiene. But there are special

classes to enable workmen to obtain certificates of competency in various industries. About 10,000 pupils attend these schools. There are industrial schools at Brussels, Antwerp, Ghent; Liege, Louvain, and other towns.

In Holland the artisans' schools have been established by private effort for training workmen. They receive Government aid, but depend also on local subscriptions. Eight or ten are in a flourishing condition in Amsterdam, Rotterdam, Hague, Arnheim, &c. The boys are engaged in these schools on useful work, capable of being sold and utilised in the school, for it has been found that being employed on *bona fide* work gives boys a stimulus which they do not feel in experimental work. The workshops are kept up to the level of modern requirements, and comprise carpenters, blacksmiths, metal workers, fitters, turners, cabinetmakers, masons, and stone-carvers. The articles made are sold to dealers, and orders are executed for the municipal authorities. Doors and windows are made for contractors. Locks, hinges, shovels, hooks, tongs, stoves, coal scuttles, are also made and sold. The lads work under directions of practical foremen. School hours are from 8 a.m. to 7 p.m. Mornings are spent in class-rooms, and afternoons in the workshops, and the full course lasts three years. Boys from twelve to fifteen, who have satisfactorily completed their primary education, are eligible for admission; and when they have completed their full course of three years, are found situations, for five years, by the committee. Employment is readily found, and better wages are paid, than to apprentices trained in the ordinary way.

In Italy apprenticeship schools do not exist as such.

In Germany, as in England, it is considered that the workshop is the best place for teaching a trade; but it is admitted freely that the science and art connected with trades must be taught to the artisan in technical schools, and that a knowledge of theory should go hand in hand with practice.

How best to give the most suitable education to a young artisan, without interfering with his daily labour, is the special consideration for the promoters of technical education.

In addition to these numerous organisations on the Continent, for the satisfactory elementary and secondary education of artisans occupying the lower grades of work in the various industries, there are other institutions for the suitable preparatory education of those intending to be manufacturers, foremen, or managers. We find the most complete and elaborate arrangements in the form of intermediate technical schools, for carrying on the extended education necessary for such men. This section, like the former, includes so many diverse forms of institutions that it is not possible clearly to separate them into classes, owing to the manner in which their methods of teaching meet and overlap each other in many ways. They are intended to offer facilities for education to the most capable pupils from the elementary schools, destined to become skilled artisans, and also to the children of foremen, tradesmen, and manufacturers, and to fit such students for responsible intermediate positions in factories, also opening still further the way onward for the most promising and persevering students to enter the technical colleges of the highest grade, and to the highest attainable positions. The schools in this section have been divided into :—1. General technical schools; 2. Weaving schools; 3. Industrial art schools.

The general technical schools have also various grades—higher elementary technical, general; secondary technical, general; building, engineering, and mining, special.

In France manual work is continued from the primary schools into many schools of the higher grades, and we notice that they seem to place greater stress on the teaching of handicraft in schools than is considered quite judicious by Englishmen, who rightly enough depend more on actual workshop practice.



We can hardly afford time to do more than take a passing glance at the numerous higher class technical schools visited by the Royal Commission. The Martinière School at Lyons was founded to afford gratuitous education in the sciences and arts applied to industry. The building cost £40,000. It provides class-rooms, workshops, laboratories, museums, library, and dwellings for the masters. Children are admitted between 13 and 15, preference being given to those of poor parents. Workshop teaching here is only carried so far as to enable the lads to take up afterwards the actual regular workshop training and practice, securing thus more time for the study of science and art bearing on industries. The course lasts three years, and about 500 students attend. A girls' school has been established also to enable girls of the working classes to fill remunerative situations.

The Municipal Professional School of Rheims is of a higher type, and is one of the best higher elementary schools on the Continent; it develops the manual labour training of the students further than is attempted in the Martinière. It was founded to give special practical knowledge to manufacturers and to educate the youths of the city of Rheims early as merchants and manufacturers. The students are drawn from the children of the elementary schools who have passed a satisfactory examination.

There is a strict entrance examination for pupils who do not possess the leaving certificate of the elementary school. The examination consists of—The rules of grammar and their applications; dictation (6 errors exclude); arithmetic, including vulgar and decimal fractions, and metric system. The boys generally enter at 13, and the course extends over three years. A general course of theoretical and practical instruction occupies the first two years, designed as a preparation for the *École des Arts et Metiers* at Chalons. In the third year the pupils are classified according to their aptitude and to the

different industrial and commercial pursuits carried on in Rheims, as follows:—Manufactures, chiefly woollens; mechanics, mill work; commerce, raw materials, wines, &c.; agriculture, especially vine growing. There are about 200 pupils, mostly the sons of traders, foremen, and artisans.

The buildings cost £25,000, and the laboratories and workshop plant, £20,000. There are weaving and spinning sheds, engineering workshops, drawing offices, chemical laboratories, physical laboratory and museum. Formerly the pupils paid £4 a year, but it is now adopted as a National school, so that it will be gratuitous, and will also receive forty Government exhibitions, but preserving its own powers of arrangement of programme of instruction.

The Municipal Professional School of Rouen is similar to that of Rheims. Eight hours a day are given to class work, and two hours to manual work. A Prussian soldier's helmet, picked up during the invasion, is kept and pointed out to the pupils by the Director as a reminder that France lost her best provinces through the superior education of her invaders.

There is a second higher grade but similar school at Rouen, where weaving and dyeing are taught.

At Amiens another school exists of the same type. It is said that Amiens, containing 66,000 inhabitants, spends more on education than any other town of the same size in France. In Austria schools are found similar to these, but in Germany higher technical schools, exactly corresponding with the French professional schools, do not exist.

This type of school affords fine opportunity to the children of artisans and tradesmen to secure good technical training in commercial, manufacturing, and mechanical industry. The workshop instruction is more advanced than is possible in elementary schools. Classical languages form no part of the teaching, and the time thus saved is devoted to mathematics and modern languages.

The Alan Glen's Institution at Glasgow is cited as the nearest approach to a school of this character in this Kingdom, where such higher elementary technical schools are greatly wanted, and where it is most important they should be established without loss of time.

The secondary technical schools are useful either for finishing the education of those intended as managers in industrial establishments, or from whence clever students can pass up to the technical University.

They are numerous on the Continent, in Italy, and in parts of Germany, and in Bavaria are known as Industrieschulen, taking a position between Real Schulen and the Polytechnic University.

Taking, for example, the Ecole Centrale at Lyons for mechanical engineers, it occupies a higher grade than the professional schools, but a lower grade than the Ecole Central of Paris or the German Polytechnics.

More time is spent on theoretical instruction than at the professional schools, while practical instruction is given which is omitted in the Ecole Centrale at Paris. Students enter at 16, and leave at 19 or 20.

The object of the school is to train managers and a superior class of foremen.

The Institute Industriel du Nord, at Lille, comprises two distinct schools, industrial and agricultural. The industrial school provides education suited for managers and directors of works for the chief industries of the North of France. The agricultural school provides necessary scientific knowledge for the sons of the landed proprietors and farmers. The buildings cost £40,000.

In Switzerland, the Technical Institution of Winterthur is an example of secondary technical school, having for its object the training of foremen. There practical work is taught in the chemical laboratory, but the general teaching is theo-

retical, the students being expected to have had some practice at actual work before entering. The building cost the municipality £40,000. For maintenance, the town pays £600, the fees amount to £500, and the canton supplies the annual deficit of £3,000.

In Germany the Chemnitz Higher Trade Institute may be taken as an example of the best secondary technical schools. It is supported by the Saxon Government, and it exerts a highly beneficial influence on Saxon industries. The building cost £80,000, and it accommodates 600 students in four schools. The higher technical school, in which instruction is specialised to suit the chosen profession of the students, whether manufacturing industries, chemical industries, or architecture. Pupils must be 15 years of age. The courses last three and a half to four and a half years. The Royal School for Foremen receives industrious young workmen who have worked two years at their occupations, and gives the requisite theoretical knowledge to enable them to become foremen and managers. The pupils are socially of a class quite different from those attending the higher technical school, and do not come in contact with them. The Royal Building School affords special technical education to all who wish to prepare for the building trades. Pupils must be 16 at entering, and must pass entrance examination. They must give their whole time to the courses for four half-years, and must have been employed at practical building work two half-years previously. The students are stone masons, decorators, carpenters, plasterers, and others connected with building construction. The Royal Drawing School is an evening school for art in all branches, the pupils being drafted from all classes.

The Royal Industrie Schulen of Munich, Augsburg, Nuremberg, and Kaiserslautern, are intended to train students for passing direct to industrial occupations. The courses com-

prise mechanical engineering, chemistry, building construction, and commercial instruction. These schools have chemical laboratories and workshops. Each student in the workshop has a capital chest of tools for his separate use. All tools and fittings for workshops are made by the students, under the guidance of foreman engineer. The boys are very fond of the work, and they find it practically serviceable when they leave the school.

In Italy this class of secondary technical school is also found in Milan, Como, Udine, Biella, and Venice.

In Austria and Holland this type of technical school has not been established.

These secondary schools for the instruction of managers of works, the students being of the age from 16 to 20, are similar in many respects to the technical departments of the University College, Nottingham, and Firth College, Sheffield, which have been recently established. Theoretical education is combined with laboratory and workshop practice, the scientific instruction being specialised and brought to bear on the chief manufactures of the districts, and is thus well adapted for the training of efficient industrial managers. There are also technical schools specially arranged as building, engineering, and mining schools, which we can only name.

In Germany we find the Building Trade School at Stuttgart, with 500 pupils, costing £50,000 to erect and £7,500 to maintain, £6,500 of this annual sum being paid by the State.

The Building Trade School at Dresden, similar to the above.

In Austria there are building trade schools in very many towns. The building trade schools at Vienna aim at giving intelligent knowledge of their work especially to builders, including architectural drawings, making *pro forma* tenders, planning and setting out work, &c.

In Austria it is a fact that not only the parents make great exertions for the education of their children, but that the young artisans work hard in summer to save money to pay for their own education in winter months, when schools are active and work abroad is slack.

In France mechanical engineering schools are numerous—*Écoles des Arts et Métiers*. Three may be named as good examples—Chalons, Aix, Angers. Others are being established at Lille and Nevers. The object is to train competent foremen and draftsmen for engineering works. These schools are provided with foundries, smith shops, pattern shops, fitting shops, and they are largely subsidised by the State.

The advantage of such advanced technical establishments consists in the fact that the students learn a number of different processes more rapidly, under the direction of foremen specially engaged to teach, than they could possibly learn them in a regular trade workshop, where each man is set to do the work he is best able to do for the profit of the concern. The disadvantage is that the students do not gain a sufficient comprehension of the value of time; they occupy themselves too much with minute details and artificial finish, which could not be allowed in the workshop in actual work for competition. These mechanical engineering schools are also established in Austria and Holland.

We also find special technical schools in France and Germany for instruction in mining and metallurgy, well worthy of the attention of English metallurgists and engineers, but rather outside of the requirements of this island at present.

The Continental weaving schools are very numerous and very valuable. They are intended to instruct not only the foremen, the designers, and spinners, dyers, and weavers in all that they ought to know in connection with their manufactures, but they also offer exceptional instruction in textile fabrics to merchants, agents, and shopkeepers. These schools are not

intended to supersede apprenticeship by teaching a complete trade or handicraft, but rather to convey practical, all-round knowledge not to be acquired in the factory. In the factory profit rules paramount; every moment must be given to quicken production; the impress of competition is on everything; no experiments, no mistakes, can be permitted—here the real life business must be carried on.

It will be sufficient for our present purpose to state that these schools are established in France, Belgium, Switzerland, Germany, Saxony, Austria, Italy. Many of these have departed considerably from their intention, and are not so successful as they ought to be. The most important and useful school is the Chemnitz Weaving School, founded in 1856, and described in Mr. Felkin's pamphlet on Chemnitz, published by the City and Guilds of London Institute.

The Continental industrial art schools may be ranged under two classes as technical schools:—1. Schools where pure art teaching is followed; 2. Schools where art in its application to special industries is studied—artistic trade schools. The latter are numerous in Germany, Austria, and Switzerland, but are almost unknown in France, where the system adopted aims at teaching the fine arts without special regard to the direct application of it to any special industry.

There is a general feeling among artists that they fail in their careers unless they become painters or sculptors of note, although even artists of great ability have difficulty in making a living in any but very prosperous times. It seems that the dignity of a painter and sculptor is admitted, while the dignity of an art designer is far from being acknowledged at its proper value, as great genius and as much training is required to form a good art designer as is needed in the painter and sculptor.

On the Continent art designers are encouraged and rewarded by the State at annual exhibitions, but at home we require to take means to acknowledge the value of art design, and to

raise the art designer to his proper rank as promoter of the industries of the country.

The higher technical institutions on the Continent for employers, manufacturers, and managers of works are numerous and well equipped. Among these taking front rank are found:—The Ecole Centrale, Paris; the Polytechnic School, Paris; the Polytechnic Schools of Zurich, Munich, Vienna, Stuttgart, Dresden, Hanover, Karlsruhe, Aix la Chappelle, Berlin, Delft, and Moscow.

In Nuremberg, a large space of their Exhibition of 1882 was devoted to exhibits from the technical schools of all parts of the country, in order that promoters and teachers of other technical schools should have an opportunity of comparing notes, and thus a great stimulus was given to technical education—and when in Nuremberg last year the author saw the closing days of another exhibition of metal work for the same object.

Those who have studied the subject of the influence of art and technical schools on the manufacturing industries of the Continent, state that they are convinced that Continental nations can only meet the competition, growing keener every day, by training their apprentices and artisans in taste and skill in such schools. That the desire for education is growing as the need for it increases, and that exhibitions such as those held at Nuremberg and Antwerp, and elsewhere, prove, beyond a doubt, that technical and art schools on the Continent are doing a great work.

In the United States of America the National education is maintained by direct taxation, under control of the States and municipalities. There are in 48 States and territories a quarter of a million of primary grammar and high schools giving education to  $6\frac{1}{4}$  million pupils. Attendance is compulsory only in the district schools among the rural population, and then only for twenty weeks in the year.



In proportion to the population more money is expended on public schools in America than in any other country in the world, and yet the supply in some districts falls far short of the requirements. The desire for education is very great, and as long as the Government possesses a surplus revenue, the necessary funds will continue to be devoted for the extension of education to every part of the country.

The institutions for higher technical and scientific education in mining, civil, and mechanical engineering in America are first-class of their kind, and eminently practical in their details, and there exist many institutions also for pure scientific teaching from which technical instruction is omitted. But the intermediate schools and colleges generally need a change in their system to meet the requirements of foremen and artisans for technical education suited to particular trades. American artisans, placed in a new unexhausted country, have been enabled, owing to their natural mechanical aptitude and industry, combined with an increasing demand for labour and labour-saving contrivances, to find abundant employment in spite of a lack of technical training. They are well taught in reading, writing, and arithmetic, and with ready wit and ambitious industry quickly pick up a trade and quickly change it, if circumstances require. The American patent laws give inventive artisans security at cheap rates and encouragement to exercise their brains. Nevertheless the waste of labour and material in America in constructive works—railways, factories, &c.—has been enormous in the past; the older railways have been or are now being reconstructed on modern systems, showing the influence and advantage of theoretical knowledge when guiding practical ingenuity.

And when technical education shall have been disseminated from the higher colleges down to the primary schools, so that the American artisans, and the children of the American artisans, shall have acquired the scientific knowledge connected

with the practical processes of their trades, in addition to their general sobriety, persevering industry, ambitious enterprise, and mother wit, combined with all the material advantages of a new world teeming with animal, vegetable, and mineral wealth, we shall find that the competition we have most reason to dread, and timely warnings to prepare to meet, will come not from the Continent of Europe, but from our own kith and kin across the ocean. Some of the principal technical institutions in the United States we may here name, but cannot find time to describe. In New York—Columbia College, Cooper Institute, Workingman's School; and at Hoboken, Stevens' Institute; the Rensselaer Polytechnic Institute at Troy; the Massachusetts Institute at Boston; the Manual Training School at St. Louis; the Maryland Institute at Baltimore; the State College and School of Industrial Art at Pennsylvania; and there are very many more than these spread and spreading throughout the States.

The general diffusion of scientific knowledge on the Continent, its appreciation by all classes, together with the adequate supply of trained managers and foremen of industrial works, is due to the large number of polytechnic and other schools for technical instruction, to the small cost of high-class theoretical and practical training brought within easy reach of all classes.

It seems to be most important to the future prosperity of Ireland that facilities for technical education, in the industries suited to our circumstances, should be offered to all who may be competent to profit by it, that our country may be given a supply of properly qualified technical teachers, and that a more abundant and suitable supply of young people may be presented for technical training.

In any scheme of technical education for artisans in Ireland, there may be five grades or sections properly defined for consideration and arrangement:—1. Primary education outside, but leading up to the point where lads of fourteen are fitted

to commence a course of technical training. 2. Daily secondary technical education for persons who can afford to devote time for two or three years to a complete system of technical education, to fit them as foremen, managers, builders, with use of laboratories and workshops. 3. Evening technical education for apprentices and artisans engaged at their work by day, with lectures, and use of laboratories and workshops. 4. Technical art education, as applied to manufactures. 5. Higher technical instruction for employers, managers, and technical teachers, with lectures, demonstrations, and opportunities for original research in laboratories. In all these grades proper and ample provision should be made alike for male and female education.

In Ireland the want of technical instruction is greater than in England or Scotland, because we want here to recover lost and to create new industries. It is well also to bear in mind that the classes for whom this special education is so urgently required are not able to pay for it, are not likely to clamour for it, and when it is provided, may need considerable inducements to cause them to accept it at first, and for some time. So that unless the State, the municipalities, or individuals, singly or in groups, will voluntarily urge on and assist the establishment of such institutions, and will maintain them even in the face of much discouragement, we may be sure that our Irish industries will remain at a low ebb.

The primary education of the children of artisans, farmers, and the lower middle classes in Ireland is almost exclusively under the National schools system.

The primary education of children of all classes, apart from questions of social position, which, by the way, are more considered in Ireland than in any other country in the world, might with advantage be the same in degree and in kind for all children up to the age of twelve; here the kind and degree of education must necessarily begin to differ, for some children

must soon after be earning their living, while others, whose parents intend them for higher industrial or commercial pursuits, or for professions, will continue their education for many years.

For children of artisans up to 12 or 13 years of age, we may be content with the National schools, provided always that rudimentary drawing, elementary geometry, and the use of ordinary tools be included in the compulsory curriculum of that system of education. If the National Board will revise their class-books, to afford better rudimentary instruction in science, and will furnish their children with this instruction as well taught as their reading, writing, spelling, and arithmetic, the children will be placed in the very best possible position, and with the requisite knowledge to enter the technical day schools or night classes.

In recommending the teaching of the use of tools to young children, let it be quite understood that such teaching is simply intended as useful discipline for the eyes and hands, an exercise for the senses of sight and touch, to quicken the perception of form, size, roughness, straightness, and measurement, and to encourage general handiness; but not to teach any handicraft, not to occupy any of the time required for other studies, and not to have any bearing upon the terms of apprenticeship.

The teaching of the use of ordinary tools to ordinary children at an early age would have a very important and useful effect, especially on the Irish nature; it would tend to break down absurd class distinctions; it would teach that there was nothing derogatory in handiwork; it would tend to abolish the stupid idea that the clerk at his desk is in a higher grade of life than the artisan at his bench; it would show that a steel file was as noble a tool as a steel pen, and even less liable to create mischief in the world; it would most surely have a tendency indirectly to develop tastes which

would turn many likely youths to honourable and well-paid manufacturing industries, instead of to the over-crowded, badly paid drudgery of clerkship.

Having briefly stated the class of primary education required, we must now pass on to consider the higher elementary technical schools which it is essential to establish in every city and town of Ireland, so distributed as to be within the reach of all humble and earnest seekers after practical knowledge.

We know, however, that such schools must be first commenced in our large cities, and spread from thence, as they become appreciated, through the length and breadth of Ireland.

As to the funds requisite for such a purpose it is not intended to speculate here further than to say that promoters of such an experiment should take care to obtain at starting a sufficient capital fund to enable them to purchase the ground rent, as well as the building and fittings required, so that no annual rent should accrue to act as a clog round the neck of the enterprise when fairly started. Judging by what such buildings on the Continent have cost, £20,000 would be the least capital sum safe to commence with, together with a fair prospect of a clear income of £3,000 a year for maintenance. If, between the Government, the Corporation, and the public, such sums as these cannot easily be obtained, the best advice to tender to promoters for acceptance would be to let the matter drop, and neither to spoil a good purpose nor to break their own hearts in seeking to provide one of the greatest blessings and benefits that could be offered to a nation unable from ignorance or apathy to appreciate or accept it.

In London the old Polytechnic, in Regent-street, has been transformed into a great educational institution for technical instruction, and has been named the Polytechnic Young Men's Christian Institute for Artisans, Apprentices, &c. The

scheme was originated by Mr. Quentin Hogg, a philanthropic wealthy gentleman, who provided the funds—£13,000 to purchase; £17,000 to equip and fit with engineering shop, workshops, laboratories, gymnasium, swimming bath; and £5,000 to £6,000 a year for maintenance, by which sum the expenditure exceeds the income. There are 10,000 members and students. There are 32 evening classes in practical trade subjects, 25 classes in technical subjects, 48 classes in science subjects, 7 classes in art subjects, and 23 classes in general subjects, such as arithmetic, book-keeping, elocution, French, German, ambulance—all conducted by trained teachers.

The higher elementary school, and the secondary school for technical education of artisans and others, might in Dublin be combined or grouped in one building; and the technical college or polytechnic, for training foremen and managers of industrial works, and teachers for primary and secondary schools, might, with great advantage, be taken in charge by the Royal College of Science, which possesses every requisite for such a purpose, excepting workshops for practical work, which could be added without difficulty.

The building for the technical schools should stand on a central site for the easy access of the artisans, whose convenience should be consulted in every step taken. The buildings should not be of an elaborate or costly character, but should be suitable, and certainly something better than a barn or stable. The promoters of such technical schools might be satisfied if they could secure an inexpensive building of temporary character, if it was suited in every way to be rendered permanent, in course of time, by a series of gradual works, carried on and executed by the students themselves, as a means of training them in the building trades, under skilled foremen as instructors. Nothing would give greater zest to the study of such branches of building construction as masonry, brickwork, joinery, plumbing, gasfitting, plastering,

and decoration, than the knowledge that the promoters of the scheme for technical instruction had determined to employ and pay the most competent of their students and apprentices to build and construct their own technical school buildings, to be at once a means of their education and a permanent monument of their skill.

The drawing-masters should be certificated teachers of drawing and modelling, chosen for their experience and aptitude in teaching applied art to artisans and students, in connection with industrial pursuits. The drawing schoolroom should be surrounded by black-boards, hung side by side on the walls, in such a manner that they may be used vertically or diagonally like desks. The proper means of lighting the room by day and by night to be well considered and arranged, as well as the warming and ventilation. Rows of desks, with seats of approved section, should occupy the centre of the floor; and tables for modelling in clay should also be provided, together with all the designs, models, and accessories common to a well-appointed drawing school. Lockers should not be requisite, as arrangements can be made for an attendant to take charge of the papers and materials of each student. Departing from the lines laid down in the higher class schools of design in this country, perhaps it would be desirable to follow the system of teaching drawing adopted in Belgium night schools, where geometrical and other forms are first copied in chalk on the black-boards. When the students have become fairly proficient in such work, they proceed to draw similar forms with charcoal on paper, outline drawing first, followed by shading; the designs and models being carefully chosen, so as to have some connection with the forms that the students will require to copy in future actual work. A bold and rapid style will quickly be acquired, better suited to the wants of artisans than the more carefully finished methods prevalent in the teaching of drawing in this country.

Lectures should also be given on the elements of geometry and perspective, illustrated by diagrams on the black-board which the class should copy and retain for future reference.

Mechanical and architectural drawing should be carefully taught in the third year of the course. Special instruction in constructive drawings for builders, stonemasons, bricklayers, carpenters, cabinetmakers, &c., should be given by teachers practically acquainted with the trades. Class-rooms, large and numerous in proportion to the expected attendance of students, should be set apart and fitted with comfortable seats. Long lecture tables for apparatus, and various appliances for experiments, should be prepared according to the funds at disposal. Controllable arrangements for the lighting, heating, and ventilation of class-rooms should be as perfect as they can be rendered. It is not reasonable to expect attention from students who are perished with cold, or asphyxiated in bad air. The courts, halls, class-rooms, and lecture-rooms of some of the most costly institutions in this country seem to have been constructed with a fixed intention of eventually altering the natural laws of air, light, and heat, to suit the circumstances established by the builders. And the attempts made by succeeding generations to effect the necessary gymnastics in heating, lighting, and ventilation are quite on a par, if they do not transcend, the genius originally displayed in creating the problems.

Workshops fitted with all *necessary* appliances, benches, tools, and machines, must be provided for each trade intended to be taught in the school, and in doing this work promoters need to be very cautious about incurring expense for machines and appliances which may soon become obsolete, or which may better be left for the student to acquire familiarity with in the actual workshop. The only appliances needed are those which will enable a competent practical teacher to instruct his pupil in practical work; and even in forming a collection of such



tools and appliances, the promoters should endeavour to impress upon teachers and students the wish to make their own tools and appliances to the utmost extent. The carpenters, students and teachers, should be willing to provide all necessary benches, lockers, and woodwork for all the other classes. The smiths and fitters, students and teachers, should reciprocate by endeavouring to supply all the ironwork needed for brackets, stays, and tools. All the students and teachers should join in the general movement for mutual benefit, and for the advancement of the institution. Materials would be supplied by the control, and rewards might be devised for the useful workers, though the experience gained should offer reward sufficient for all the earnest students. Every care should be taken to induce the growth and maintenance of a healthy and vigorous *esprit de corps*, without which interest and progress must fall off in time. Power can be most easily supplied for lathe work, &c., by gas engines. Foot or hand driven lathes will not be found sufficient for the training required.

Elaborately furnished mechanical engineering and fitting shops can hardly be included at first in any scheme for technical training of artisans, though they are to be found in many such schools in England and abroad. Laboratories for chemical and physical practical instruction, with all the scientific apparatus essential for really good and accurate work, would form a most valuable addition to any technical institution ; indeed they are essential in schools for higher technical education. The high cost of the equipment and proper maintenance of such important aids to technical study must be considered and provided for, and, unless ample funds are forthcoming, promoters of technical institutes for artisans must be contented to work without them, by utilising, as far as they may, such laboratories already established as they may be able to gain access to when special occasion requires.

A library of suitable books cannot be too large or too com-

prehensive, and should be open as a lending library to students, under necessary restrictions of course. A museum, containing specimens of interest to industrial students, may be economically formed by degrees and with greater advantage to the students than if large sums were expended in purchases for its immediate establishment on a large scale. The students will help in the acquirement of specimens; they will know something concerning each fresh addition; and they will take an interest in the work of forming and classifying the collection, year by year, which they could not be expected to feel in a ready-made museum purchased by any special grant. The exhibits in such a museum might well include raw materials, minerals, woods, manufactures in every stage of progress up to completion, tools, instruments, machines, models, plaster casts of vases, busts, ornaments, drawings, engravings, designs, works of art.

The technical college at Finsbury affords a good example for Dublin to follow in establishing a technical institute. Its objects are to educate:—1. Persons wishing to receive a scientific and practical preparatory training for intermediate posts in industrial works. 2. Apprentices, artisans, and foremen who are engaged by day, and who desire to receive supplementary instruction in the art, practice, and in the theory and principles of science connected with the industry in which they are engaged. 3. Pupils from middle class and other schools who are preparing for the scientific and technical courses of instruction to be pursued at the City and Guilds Institute, and under the Science and Art Departments at Kensington. The four chief divisions or faculties of the college are: applied mathematics and mechanical engineering; applied physics and electrical engineering; applied chemistry; applied art. The college is under the direction of a principal; each department is controlled by a professor, assisted by demonstrators; lecturers and teachers are engaged for special

subjects, and skilled artisans are employed as workshop instructors.

Finsbury College and the Central Institute, Kensington, should be visited by all who wish to know what technical education really means—one visit will be worth 100 definitions.

The day school of such an institution should not seek to occupy the highest grade in technical education, because it is not intended for civil engineers, chemists, architects or teachers, in whom a more exact knowledge of theoretical science is required when entering higher colleges than would be required from students entering here; but, on the other side, the day school is not an apprenticeship school—it will teach no actual trade—but it is a school in which lads from 14 to 17 years of age, intending to become mechanical engineers, electrical engineers, builders, or to enter any of the trades allied to chemistry or the arts, may receive both practical and theoretical instruction in the application of the principles of science to the industry they intend to follow.

The best definite course of study will be given to the student; he will be engaged about seven hours a day for two years in laboratory instruction, tutorial work, lectures, exercises in mathematics, mechanical and freehand drawing, workshop instruction, and also in French and German.

The student may thus gain, if he will, a wide and cultivated acquaintance with science and art in connection with his practical life industry. He begins his course as a school-boy, but follows it as a student-artisan.

At chemistry the chemical students work from 10 to 12 hours per week in the laboratory; and in other branches they will work in wood and iron in the workshops—for instance, in the iron workshop they will be taught to produce a fairly smooth flat surface on iron by the use of chipping chisels alone; to grind various tools; to chip and file true to square, straight-edge, and bevel; to drill by hand and machine; to

screw and tap; and to acquire a knowledge of the working and construction of lathes.

In the joinery workshop they will be taught—Sawing, planing, and paring wood to given size; squaring and marking out, sharpening tools, methods of joining, wood turning.

The complete course of mechanical engineering for two years is divided out as follows (first year, 34 hours; second year, 38 hours per week):—

	First year. Hours weekly.	Second year. Hours weekly.
Mathematics - - -	4	4
Practical Geometry and Machine		
Drawing - - -	7	—
Mechanics Lectures - -	2	2
Mechanical Laboratory - -	2	6
Mechanics Exercises - -	3	—
Machine Drawing and Mechanism	—	10
Workshop Practice - -	5	7
Physics Lectures - -	2	—
Physical Laboratory - -	3	—
Electrical Technology - -	—	1
Chemistry Lectures - -	—	2
Chemical Laboratory and Tutor	—	4
Freehand Drawing - -	3	—
French or German - -	3	—
German - - -	—	2
	<hr/> 34	<hr/> 38

In applied physics and electrical engineering the main object is to train the students in the application of the laws of physics to industry—to show them how, by such means, operations can be improved or cheapened, partly by lectures and partly by the laboratory work of the student, the knowledge gained being practical as well as theoretical. Arrangements are

made in the laboratories for organised series of useful experiment, the students working in groups, and recording notes of their experiments and results for the professor.

The complete course of electrical engineering for two years is divided as follows (first year, 35 hours ; second year, 38 hours per week) :—

			First year. Hours weekly.	Second year. Hours weekly.
Mathematics	-	-	4	4
Geometry	-	-	2	—
Mechanics Lectures	-	-	2	—
Mechanics Exercises	-	-	2	—
Mechanical Laboratory	-	-	2	—
Machine Drawing	-	-	—	3
Workshop Practice	-	-	3	6
Electrical Technology Lectures	-	-	1	3
Physics Lectures	-	-	2	—
Physics Tutorial	-	-	—	2
Physics Exercise	-	-	1	2
Electrical and Physical Laboratory			8	10
Chemistry Lectures	-	-	—	2
Chemical Laboratory	-	-	—	4
Freehand Drawing	-	-	3	—
Geometrical Drawing	-	-	2	—
French or German	-	-	3	—
German	-	-	—	2
			<hr/> 35	<hr/> 38

Importance is laid on making French and German obligatory on advanced students, as being the only literary training offered, and very valuable as enabling artisans and foremen to read for themselves, in French and German trade journals, the accounts of new processes and new machines, which may prove of great service.

The evening schools have been already a great success in London, not only in Finsbury College, but in the Polytechnic, and wherever they have been started. Definite courses of instruction are arranged to occupy the students for two or three years on four or five evenings in the week, and these schools are crowded.

One of the objects to be kept in view by those convinced of the necessity for technical education of artisans, is to endeavour to bring the same conviction to the artisan himself. He wants to be taught to see that he needs a combination of theoretical and practical training—in fact, technical education to enable him to deal with unexpected circumstances and difficulties, which every artisan is certain to meet—that he requires a comprehensive grasp of the entire area of his work, to know a great deal more than he can ever learn in his workshop alone, and that otherwise he will be swept aside by the workmen of the Continent and of England and of America.

Probably the best training for lads intending to become mechanical engineers would be to attend schools, up to the age of fourteen, where they would, in addition to a good primary English education, receive a knowledge of drawing, elementary geometry, and the use of tools; then they should pass into a technical day school, such as the Alan Glen or Finsbury Institute, for two years, where they would obtain a grasp of the scientific knowledge underlying their future trade; then entering, at sixteen, into practical work by day, and continuing their attendance at evening technical classes for three years, and competing for certificates and honors in the Kensington Science and Art and in the City and Guilds of London technological examinations.

The primary, secondary, and higher grades of a sound general and technical education, in all suitable industries, should be arranged, provided, and brought within reach of every capable person in Ireland. It is undoubtedly the duty

of the State to assist liberally in this work, for it is now admitted that the prosperity of the State is bound up with that of the artisan, and that the prosperity of the artisan is dependent upon his technical education. The State, therefore, should take the initiative in this work, so far as it appears clearly to be for the general benefit of the community, while requiring individuals and trades particularly interested to contribute a fair proportion towards the expenditure. It would be a mistake for citizens to expect or desire the State to do everything.

In a free country there will ever be a certain readiness in its citizens, even amounting to pride, in contributing individually towards the foundation and maintenance of institutions for the public good. The amount of voluntary contributions of individuals in the United Kingdom for such purposes forms a source of wonder and of envy to foreign nations. It would be a grievous national loss if this beneficence of individuals was transferred as a mere duty to the State.

In concluding this rather tedious and technical paper, we may recapitulate the requirements of technical school promoters:—

1st. That primary education in the National and other schools in Ireland be remodelled and made compulsory.

2nd. That technical schools, as described, be established in every city and town in Ireland, to prepare young artisans for their trades, both in day schools before they engage in actual work, or as continuation evening schools during their apprenticeship term.

3rd. That the apprenticeship customs be encouraged and re-established, with clauses in indentures to compel apprentices to attend evening technical schools.

4th. That employers support and encourage technical schools, and employ only such artisans as show the desire for technical improvement by attendance on technical classes.

5th. That the State aids liberally with funds the efforts

made to establish and maintain primary, intermediate, and higher technical education, through the length and breadth of the land.

6th. That the artisans and apprentices should themselves appreciate and take advantage of the benefits offered by technical schools.

In olden times success in manufactures and commerce was greatly due to local advantages, but now, owing to the progress of engineering, industrial competition has become one of intellect, and the best educated nation, as well as the best educated artisan, will henceforth be the most prosperous.

This paper has been written in the hope that it may, in some degree, tend to show the greatness of the need for the technical education of Irish artisans, and may thus far help to supply that need, and secure the resurrection and future success of our lost and languishing industries.

Professor FIGOT, Royal College of Science, said the Institution and the public owed a debt of gratitude to Mr. Maguire for his elaborate and exhaustive paper. He considered there were two classes of schools needed in Ireland—the first was a class of schools similar to the normal schools in France and Belgium, which were purely for the purpose of teaching the higher branches of scientific education. This might be supplied by the College of Science, the Queen's Colleges, and probably Trinity College as well. The other class of schools should be for teaching the mechanical portions of the work of artisans in their various branches. The first class of schools should be maintained by the State, the second class—artisan schools—should be assisted by private enterprise.

Mr. JOHN A. C. RUTHVEN observed that the chief want experienced by employers of artisans in Ireland was not so much that they needed ideas as that it was difficult to make



them carry out adequately the ideas presented to them. His belief was that what the Irish workman wanted was handiness—the capacity to execute and carry out his work effectively. Irish artisans required to be taught to finish their work as well and as satisfactorily as was done elsewhere. It was no use disguising the fact that you could not get work finished, as a rule, in Ireland so well as it was done on the other side. Mr. Davitt, who took a great interest in this matter, and had done good service in calling public attention to it, fell into the mistake of telling Irish artisans that they were just as good as could be found in any part of the world. That was one of the great mistakes Irishmen were apt to fall into. In his own business, when calling the attention of an artisan to the defects in his work, the frequent reply was—"Sure it is as good as anyone else could do it." Irishmen must be got to understand that they had a great deal to learn—that their brethren in other countries in many respects were superior to them, and if they once were convinced of this there would be more hope of improvement. He feared it was not in the character of Irishmen to become good tradesmen, as a rule, and that was one reason why technical schools had not been established in the country.

Mr. J. C. SMITH (Hon. Sec.) differed from the observations made by the last speaker as to the capacity of Irish workmen. His experience showed him that they were naturally more intelligent than those of other nations. Indeed, sometimes they were too intelligent.

Mr. H. IVATT, Mr. J. ANGELO FAHIE, and other members having spoken,

The CHAIRMAN said his opinion also was that good artisans were produced in Ireland. No doubt they laboured under great disadvantages as compared with the artisans in England,

and still more so when put in competition with Continental or American workmen. Referring to technical instruction, he instanced the admirable training school at Artane, where young lads were taught various useful handicrafts in the most efficient manner, and fitted to become excellent members of society. In conclusion, he proposed that the thanks of the Institute should be accorded to Mr. Maguire for his able and interesting paper.

Mr. MAGUIRE, in responding, said that in directing attention, through the medium of such a body as the Institution of Engineers, to the important subject of technical education his object was achieved. He was glad to find the subject growing daily in interest, and receiving a large amount of public attention. One illustration of this fact was found in the National Model Schools, in which classes were now established where instruction was given to pupil teachers in the use of various tools and handicraft occupations. This was an important step in advance, and he trusted would be persevered in and followed out.

[3rd March, 1886.]

J. A. F. ASPINALI, President,  
in the Chair.

The Annual Report of Council for 1886 was read by the Hon. Secretary. and adopted unanimously by the meeting.

COUNTY WORKS IN IRELAND. By FREDERICK WILLSON,  
B.E., A.B., & Ex. Sch. T.C.D., Member.

Plates II., III., IV.

IN bringing this subject before this meeting, the author apologises for writing on a subject generally so well known, and so much better understood by most of the members present than by himself; his object being to give an outline of the duties of the office of a County Surveyor, which may be of some use in directing young engineers preparing for that office.

The duties of a County Surveyor are laid down in the 6 & 7 Wm. IV., and other Acts relating to that office, and may be roughly stated as, attending to, and giving professional advice at presentment sessions, on contemplated works, including approximate estimates of such works, the preparation of the necessary plans and specifications for works there approved of; reporting on such works, their necessity and utility, and also on the state and progress of existing works to the Grand Jury, at their meetings, and a general supervision of all works in progress of construction, including the maintenance of roads. The Surveyor will also have to report to the Grand Jury on the effect which contemplated railways may have on the public works in his charge, and on all tramway schemes which may be promoted throughout his county, both in an engineering and financial point of view; should any

tramway be constructed through his county, under the Act of 1883, he will be, to a considerable extent, responsible for the proper construction of the same, and may be called upon, in case of a guaranteed line, to arbitrate as to the amount of the guarantee which may have to be paid by the guaranteeing baronies or districts during any half-year, which will necessitate his auditing the accounts of the tramway company from time to time.

The class of works which a County Surveyor may have charge of may be roughly stated as follows :—

1. Maintenance of existing public roads and paths.
2. Maintenance of streets in county towns.
3. Maintenance of bridges and retaining walls.
4. Maintenance of public buildings, such as courthouses.
5. Improvements and repairs of old roads, and prevention of slips.
6. Construction and repairs of piers and quays.
7. Construction of new roads.
8. Construction of bridges, and retaining walls.
9. Tramway construction.
10. Sea and river walls.

In most counties in Ireland the greater bulk of the new works are now constructed, but in some counties there are still new roads and bridges to be constructed ; the bridges generally vary from 10 to 40 feet span, but much larger are sometimes required ; but the greater proportion of the work given in charge to a County Surveyor will be works of maintenance.

#### MAINTENANCE OF ROADS.

The maintenance of public roads should include the keeping open of side drains, cutting of hedges, providing for under-drainage, removal of mud from the roads, and mud banks from the sides of the same, and, above all, the proper application of a sufficient quantity of material to preserve both the longitu-

dinal and cross section of the road ; it must be remembered that before any improvement can be effected in the road it must be brought, in both cases, to a proper section, and that the application of material to effect this purpose—in the case of a road from which the traffic cannot be diverted during the repairs—should to a great extent be gradual ; for if too much material is heaped at once on the road it will, unless the material is well rolled in, tend to soften the surface for a considerable time. When rolling is not resorted to, the material should be applied in large compact patches, one stone deep, and generally much longer than their width, applied to the lowest parts of the surface, not too close to each other, and in such a manner as to distribute the traffic as much as possible over the surface ; the cleaning of the road should be well attended to, and the freshly applied material levelled down and raked into its place from time to time, according as it is disturbed or partly beaten in by the traffic. The constant application of material, and attention to the wants of the road, are of the greatest importance, and will secure a better road than the less frequent application of a larger amount of material put on at one time ; in fact roads should be always more or less under repairs, though the bulk of the material should go on during autumn and after frost. In some states of weather, as in fogs, the material will stick to the wheels of the vehicles passing over the road, which causes much damage to the road ; watering the road or street during such times is a partial cure. A great improvement in repairing streets in county towns can be effected by slightly picking the surface first before applying the material, and then ramming down the material with a heavy rammer used by hand.

With regard to the kind of material to be used in making or repairing roads, the hardest and toughest kinds are the best, such as granite, trap rock, limestone, sandstone ; for country roads limestone is the best. The stone should be broken as

evenly as possible, and not larger than will pass through a two-inch ring.

In the County Fermanagh the principal kinds of stone used in repairing the public roads are, limestone, yellow and red sandstone, some pudding stone, rotten sandstone, rotten free-stone, and mica schist, the latter are principally used in our mountain districts; about half the roads in this county are made of limestone, the rest principally of sandstone and free-stone. In some of the mountain districts the metal is altogether of rotten sandstone and mica schist, both of which make bad road metal, and the roads constructed with them are consequently very difficult to keep; the broken sandstone disintegrating into sand, and the mica schist almost into mud after the first winter's frost, it has then to be scraped off, and replaced with fresh broken stone. The only time this class of road has a fairly firm surface is when it is half wet; for in dry weather the sand becomes quite loose, and therefore difficult for vehicles to travel over, and in wet weather it is altogether too soft. The mica schist is the worst for road metal, being almost useless for even any moderate traffic. Neither of these materials should be used if it can possibly be avoided, but there are mountain districts in which no other stone can be got, and into which it would be practically impossible to bring limestone. So far as country roads are concerned, as a rule limestone if not too rich in lime, will give the best surface, and the author prefers to use it wherever practicable. Hard greenstone and pudding stone give good roads. The latter requires special care in breaking, which is one of the difficulties in using it, as it will be found very hard to get the men to give proper attention to this, and if not well broken the round surface of the parts it is naturally composed of is an objection. In using sandstone the hardest class should be selected. The sandstone quarries in some parts of this county give first-rate curbing for footpaths.

There are at present about 890 miles of roads under maintenance contract in the author's charge. In the year 1872 these cost an average of 8·84 pence per perch, and at the present time they are costing an average of 8·44 pence per perch per annum, under the five years' maintenance contract system.

With regard to the improvement of old roads—as many badly laid out, badly formed, and badly fenced roads and lanes are now being, and, no doubt, will continue to be, put under public presentment, the very first difficulty that will be met is that the presentment sessions, as a rule, will not go to the expense of putting these roads into a proper safe state before casting them on the county for maintenance contract; in fact they will do nothing but repair the existing surface. Many of these lanes do not exceed 10 to 12 ft. wide, and the sessions will limit the repairs to that width, and as a rule will not improve the fencing of the roads. It is to be feared there will be an increase of this evil in the future. In this county the author brought a test case before the Assize Judge, as he held that these roads should be made 16 ft. wide before being made maintenance contract roads. That in fact the presentment, if the road had not been a county road before, should include the widening of the road to 16 ft., and fencing it in, but the matter was decided against him. In a few words, the improvement of old roads ought to include the alteration of the direction where objectionable, the widening to 16 ft., and complete fencing in of the road, the filling of all gripes between existing fences, and construction of drains outside the fences, as well as the proper paving and stoning of the surface; hedges should be dressed and cut down to 3 ft. 6 in. high over the road.

With regard to the quantity of material required for the maintenance of a road it varies very much, and depends on the wear the road is subject to. The principal causes of wear are—wear from wheels, wear from horses' feet, &c., and wear

from rain, frost, and atmospheric changes. Macadam puts the annual wear of metalled roads at from 1 in. to 4 in. deep in the year. Hence knowing the length and width, and vertical depth of wear we can find the quantity:—

Let  $Q^t$  = quantity required in tons of metal,

$d''$  = vertical depth of wear in inches,

$A^{yds}$  = area of road in superficial yards,

Then  $d'' = \frac{32 \times Q}{A}$  if not rolled in.

$d'' = \frac{24 \times Q}{A}$  if rolled in.

For county roads we may take the annual wear at from 0·2" to 1·00", but for towns much greater. To illustrate the formulæ three cases in this county (Fermanagh) are given. The first case is that of a road of 505 perches long with a width of carriage-way of 21 ft.; about 600 tons of metal are required to keep this road. Its superficial extent is 19442·5 yards unrolled—

$$\therefore d'' = \frac{32 \times 600}{19442\cdot5} = 0\cdot988 \text{ of an inch nearly;}$$

in the second case  $d'' = \frac{32 \times 200}{20135\cdot5} = 0\cdot312''$  nearly;

and in the third case  $d'' = \frac{32 \times 60}{15620} = 0\cdot13''$  nearly; the last case

being that of a country road of hardly any traffic, hence the following:—

Length of Road, in Perches	Width, in ft. of Carriage- way	Quantity of Material, in Tons	Depth of Wear, in Inches	Quantity of Material, in Tons per Perch
505	21	600	0·988	1·19
523	21	200	0·312	$\frac{2}{3}$
710	12	60	0·13	$\frac{1}{4}$



In fact, from a general investigation, it will be found that for ordinary country traffic and in country towns the quantity of material required for the maintenance of a road may be taken at from 1 cubic yard to every 5 perches, to  $1\frac{1}{2}$  cubic yards to every perch, of the length of the road of the ordinary width of from 18 to 21 ft. This is, of course, a very rough approximation, but a help in indicating the quantity of material, which may be required, where no certain data is known, from which to calculate. The quality of material used, must, of course, to a great extent, depend on what kind of stone can be obtained in the district. The cross section of the road should not be kept too high in the centre, but just high enough to prevent water lodging on it. A rise of 1 in. in 4 ft. towards the centre is quite sufficient. There is no provision for rolling in the stone used in repairing country roads, and it is feared it can never be carried out under the present contract system. Too much attention cannot be paid to the breaking of the stone into pieces of as nearly as possible the same size ; and a  $1\frac{1}{2}$  in. ring would be a better size than 2 in., but will increase the price of the stone.

#### CONSTRUCTION OF NEW ROADS.

The laying out of new roads in this country is much facilitated by our excellent Ordnance maps. On these, when walking over the ground, one can mark the rough limits beyond which the road should not extend in either directions from the centre line, in order to give the least fillings and cuttings. This having been carefully done, and the best line within these limits marked on the map, the levels can be taken, and the Ordnance Survey corrected for any changes made in fences, &c., thus giving a ready map of the intended line, and the sections corresponding with this centre line then made. In this country no new road can, by Act of Parliament, be made less than 16 ft. wide between the fences, and

for county roads from 16 to 21 ft. is a fair width, and a road 18 ft. wide will now be found to meet the requirements of most country places. The depth of material required has been stated by Dumas at from 4 to 8 inches, formed after Macadam's method; but in many roads this is not quite sufficient, and there should be a rough pitching of coarse broken stone laid underneath the finer material. Many of our existing roads are very difficult to keep in proper repair, especially after frost, for want of such a rough paving.

The cross section of a new road should have a somewhat greater fall from the centre to the sides than what it is eventually intended to have, for the centre of the road will be more consolidated by the traffic than the sides, the traffic tending to keep the middle or highest part of the road; hence for a new road the surface, if not rolled, should have a fall of about 1 in. in 3 ft. from the centre to the sides. Fig. 1 is the usual cross section adopted by the author for new roads in this county. The lower strata being a rough paving, compactly laid 6 in. deep in the centre and 4 in. at the sides, covered with 6 in. deep of finely-broken stone (broken to pass through a 2-in. ring), and blinded with a thin coating of good gravel; as little gravel as possible being used. The path being constructed of 3 in. deep of coarse broken stone, covered with 3 in. of stone (broken to pass through a  $1\frac{1}{2}$  in. ring), and over that 3 in. deep of gravel, having a fall from the fence towards the road of 1 in. in 2 ft., and bounded at the road-side with a curbing of roughly-dressed stone 10 in. wide by 12 in. deep, and in lengths of not less than 18 in. Fig. 2 shows the section in case of the road being constructed with a path. In towns the traffic being much greater, the paving is made 6 in. deep for the full width of the road, and the stoning increased to 8 in. deep. The whole curvature being cut out of the formation level. In large country towns the cross section should be somewhat as in Fig. 3; the centre

portion of the paving being regularly laid of stone about 9" x 6" x 6".

The drainage of the road in all cases must be provided for. In the case of country roads, by side drains, outside the fences, soft places and springs in the surface being drained by stone drains across the road, filled with broken stone to about 18 in. deep, and of the form shown in Fig. 4, at intervals of about 30 ft., apart where the soil is very wet, and, if on rising ground, made right up the slope, and discharging into the side drains; in towns longitudinal covered main drains will be required, as well as cross drains discharging into the nearest outlets, the water-channels of the streets being connected with the main drains by proper gulleys.

The longitudinal section of a country road should be laid out so that if possible the greatest incline be not more than 1 in 33; but 1 in 20, and 1 in 15 have been used; and in this county (Fermanagh) on one of our leading roads, which has to cross a mountain ridge, one of the inclines is as bad as 1 in 15 for a considerable length.

In the construction of roads through bogs the great difference from that shown in Fig. 1 is the addition of a second longitudinal drain at each side of the road, at about 16 ft. from the ordinary side drain, and the laying of fascines to float the road over soft places, or a layer of heather scraws of about 8 in. deep, with the heather turned down, and if possible, covering the whole of the formation level with about 8 in. deep of clay before laying the paving for the foundation of the road. In passing over very soft, deep, short bogs, timber may have sometimes to be used. About eight years ago a road was carried across a deep swamp in a bog, so soft that there was no means of fencing the road in the ordinary manner; the length of road was about 10 perches; a timber platform was constructed as in Fig. 5 and 6, and a road constructed over this about 12 ft. wide, of about 6 in.

of metal, laid on top of rough fascines; the work has been so far satisfactory, but will have to be renewed in time.

Fig. 7 is a cross section of a country road proposed to be constructed along a steep hillside in this county. The surface of the road should have a slight slope towards the hill, and the water from the channel to be let off at frequent intervals, as shown by the dotted line.

It is impossible in a short paper like this to even indicate what may have to be done under the several headings given. Reference is only made to those which come most into practice in this county.

#### CONSTRUCTION OF BRIDGES.

The bridges which have to be constructed are, as a rule, small, but in many counties large bridges have to be constructed and repaired from time to time. One of the bridges (Fig. 8) constructed some time ago for road purposes in this county consisted of two arches of 30 ft. span each, built on a pile foundation. The length of the piles was from 18 to 20 ft.; driven by a piling machine, worked by hand with a windlass; the weight of the ram 8 cwt.; the final fall 20 ft. The piles were driven home to firm ground; the diameter of the piles varied from 12 in. to 14 in. The piles were connected at their top by a stout waling 9 in. by 6 in. bolted to them. The space between the head of the piles was excavated from 18 in. to 24 in. deep, and filled with concrete to the level of the top of the piles. On the top of the piles and firmly spiked down to them were placed a set of longitudinal timbers 12 in. by 6 in. section, and the space between these again filled up with concrete; another set of cross timbers, of same section, were spiked down to these and the space between filled up with masonry; over this a course of large flags was laid, and on this the masonry was founded, the principal dimensions of the bridge were as follows:—

				Ft.	in.
Span of each Arch	-	-	-	30	0
Radius	-	-	-	18	9
Rise	-	-	-	7	6
Height of Abutments to Springings	-			8	0
Thickness of Abutments at Springing	-			8	0
Thickness of Pier at Springing	-			5	0
Length of Parapets	-	-	-	115	0
Depth of Key in Centre	-	-		1	9
Depth of Ring at Springing	-	-		1	9
Length of Ring on Soffit alternately 1ft. 6in. and 2				6	
Height of Parapets over finished road	-			3	0
Width of Roadway between Parapets	-			18	0
Depth of Coping-stones 12 in., width					
18 in., length not less than 2 ft.					

The ground upon which this bridge is built is of a very soft nature, composed of a layer of soft mud about 2 ft. deep, underneath which there is a layer of pretty hard gravel of from 1 ft. 6 in. to 2 ft. thick, the strata dipping somewhat from north towards south. Underlying this there is a strata of soft running sand, so soft that an iron rod, when driven through the above strata, could be easily pressed down with the hand. This latter strata varied from about 12 to 17 ft. deep under the bed of the river, and lay upon a firm bed of gravel, hence the necessity for piling. The pier was so constructed that there is no vertical joint in the masonry at any of the angles forming the cutwater ; the masonry in the face-work of the bridge is a kind of broken ashlar, the backing good rubble, the sheeting ashlar, the metalling over the bridge for the road, in all, 9 in. deep ; the total cost, including the lowering of a small hill and some fencing, was £1,500. All joints in the masonry were raked out and pointed in Portland cement mortar in the ratio of 1 cement to 3 fine, clean, washed sand.

This bridge is on the main road from Enniskillen to Belturbet, and is built in place of an old bridge which fell in

1857 ; plans were then made for a bridge of three arches, but owing to the difficult nature of the foundation, no contractor could be obtained for the work ; a rough wooden bridge was then put up in the place. In 1882 the plans above referred to were made, and a contractor having been obtained, the work was completed in a satisfactory manner in 1883. At the end of this paper is given a table of the principal dimensions of some of the bridges designed and constructed in this county.

In repairing and maintaining existing bridges, works will have to be executed of every possible kind. Some of the arches of old bridges in this county have become defective through the arch opening longitudinally, sometimes near the centre of the road, and sometimes near the rings. The latter is principally due to the want of proper bonding of the ring-stones into the sheeting, and has led to the adoption of the large bond indicated in the table above referred to. In some cases the rings are tied together across the road with wrought iron tie-bars of about  $1\frac{1}{2}$  in. in diameter, passed through either iron bars or oak slabs, laid against the outside of the rings, at each side of the bridge, catching as many rings as possible ; these being tightened up, the road and arch has then been opened, the crack cleaned and washed out, and then filled with Portland cement and sand, in the proportion of 1 cement to 4 sand.

#### CONSTRUCTION OF PIERS AND QUAYS.

In this county our piers are principally for the purpose of lake navigation, and used for ferry and steamboat purposes. Those used for ferries are constructed from the end of the public road to low summer level, and are of the form of a slip about 16 to 18 ft. wide, with a regular longitudinal fall. They are formed of a facing of solid dry stone wall, about 3 ft. thick, built in regular courses, with squared joints, the centre filled in with stone and gravel, and the surface paved with large flat stones of not less than  $9'' \times 6'' \times 12''$  to each stone, with a large proportion, about

twice that size; the coping for the wall is of not less than  $12'' \times 18'' \times 24''$  each stone.

Reference is only made to one pier used for steamboat purposes, a section of which is given in Fig. 9. The foundation is soft, and the pier built on a timber platform; the length of the pier is about 293 ft., extending about 270 ft. beyond high-water mark, giving a depth of water at the end of the pier of 4 ft. in summer, and 12 ft. in winter. The width of the pier is 10 ft. between the parapets, which are only 1 ft. 6 in. high. The road approaching the pier is 16 ft. wide. The face-work of the masonry in the pier is a solid dry stone wall, about 3 ft. thick, built in regular courses, with squared joints. The centre of the pier is a filling of rough rubble. The pier is protected all round by a row of piles  $9'' \times 6''$  driven about 10 ft. apart, waled with two rows of timbers  $7'' \times 6''$ , one at the level of low water, the other at the level of the paving. The surface of the pier is partly formed of Macadam, and partly of a paving of stones of about the same size as used for the ferry piers; the Macadam is about 12 in. deep; the parapets are formed of single stones 1 ft. 6 in. high, and  $24'' \times 18''$  each stone.

#### RETAINING WALLS.

The retaining walls which may have to be constructed under county presentment, are, as a rule, for the support of roads, or in connection with bridges; in general the mean thickness of a retaining wall should not be less than one-third of its height, but the thickness must vary very much according to the position of the wall and the nature of the ground at its back. In county works they are generally built either plumb or with a batter on the face. In one case the retaining wall for a bridge was 14 ft. high, and 5 ft. 6 in. thick at the foundation, and for 2 ft. high, 4 ft. 6 in. thick at that level, having an offset of 6 in. at both back and front; the wall had a face-batter of 2 in. to the foot, and was 1 ft. 9 in. thick at the road level, with an offset of 3 in. at 4 ft.

under the road level, and of 6 in. at 4 ft. deeper; the ground at the back of the wall was made ground. The retaining wall at the mill bridge, near Irvinestown, was 13 ft. 6 in. high, 5 ft. 6 in. thick at the foundation, with a footing course 18 in. deep; the face is plumb, the wall 4 ft. 6 in. thick for 4 ft. high over the footing course, 4 ft. thick for 3 ft. higher, 3 ft. 6 in. for the next 2 ft., and then diminished for every foot of height by a 6 in. offset at the back to the road level, where it was 2 ft. thick. A section of each wall is given in Figs. 10 and 11.

As a rule, the following formulæ will give the mean thickness required for such a wall, the wall being built of good rubble masonry set in lime mortar, with vertical sides:—

Let  $T$  = the mean thickness in feet,

$H$  = the height of wall in feet over the ground,

$C$  = a constant;

Then  $T = C \times H$ , where

$C = 0.52$  in case of semi-fluid earth,

$C = 0.28$  in case of earth in its natural state,

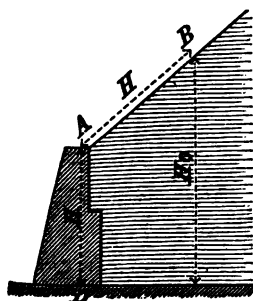
$C = 0.32$  in case of earth soaked with water.

Should the wall have an external batter, then make

$T$ , the mean thickness =  $0.86$  of  $T$  (as above found)  
for a batter of 1 in 12.

$T$ , =  $0.74 \times T$ , for a batter of 1 in 6.

Should the wall be surcharged, then along the slope of the



bank find the point  $B$ , so that  $AB = H$ . Measure off  $H_0$ , and use this for the height, instead of  $H$  in the previous formulæ. In long walls, counterforts should be added at the back of the wall, at about 25 feet apart.

In dry rubble retaining walls, as they are usually constructed, it should be remembered that the wall being



generally built of a fair facing, backed with rough stone work, the latter cannot be counted upon in the thickness of the wall, as it really is no better than part of the filling at the back of the wall, and the thickness of the face-work is the only part that can be safely relied upon.

#### PUBLIC BUILDINGS.

The works in the case of public buildings are principally the maintenance of courthouses, &c. When holding the office of County Surveyor of Westmeath, one of the first works the author had to get executed was the re-roofing of a portion of the gaol. The building had been formerly roofed in three spans, and he determined to replace the old roof by a roof of one span, the net span being 36 feet. The following are the dimensions of the queen-post trusses used:—Tie beam  $10\frac{1}{2}'' \times 5''$ , queen posts  $5'' \times 4''$ , principal rafter  $5'' \times 6''$ , straining beam  $7'' \times 5''$ , purlins  $8'' \times 5''$ , common rafter  $4'' \times 2''$ , wall plates  $6'' \times 6''$  and  $12'' \times 6''$ , the rise 8 feet, and the trusses 9 feet apart. The slating was carried right over the walls. The sewage, warming, and ventilation of public buildings must also be attended to; but these questions cannot be entered into in a short paper like this.

#### TRAMWAYS.

Since the passing of the Tramways Act of 1883 tramways can be constructed along the sides of public roads, and baronial guarantees may be obtained from Grand Juries, not exceeding five per cent. on the fully paid-up capital. After the opening of the line for traffic, the Treasury will contribute to the Grand Jury in aid of this guarantee two per cent. of a guarantee of five per cent., or in that proportion if the guarantee be for less than five per cent.; but from the time any capital is fully paid up, the whole guarantee must be paid on that capital by the guaranteeing districts. Had the grant-

ing of a guarantee taken the opposite direction, and the Treasury contributed the whole guarantee in the first instance, and then made the baronies or guaranteeing districts contribute a certain proportion of the guarantee to them, the money would probably have been obtained at a much lower rate of interest. In this county the guarantee on the Clogher Valley Tramway is at the rate of five per cent. per annum on the fully paid-up capital.

Whether the line is guaranteed or not a considerable amount of responsibility will be thrown on the County Surveyor, but the Act does not give him anything like sufficient and immediate control over the construction of the line. The author does not intend to enter into a full description of the Clogher Valley Tramway which is now in progress of construction in this county. The whole line extends from Tynan in the County Armagh to Maguiresbridge, in the County Fermanagh, passing through the County Tyrone by Aughnacloy and Fivemiletown. The gauge is 3 ft., the maximum weight authorised by the Order in Council on any pair of wheels is 8 tons, the maximum speed 25 miles per hour on any part of the line which is more than 30 ft. distant from the centre of the road. The rail 45 lbs. (steel), the joints made with a sheath and one fish plate 17 lbs. to the pair, they are 14 inches long each. Where the tramway is constructed along a public road, and not on the same level as the surface of the road, there must be a width of 18 ft. of road left between the dwarf walls or the curbing of the tramway platform and the footpath on the opposite side of the road; or in case of no footpath then between the same and the fence. In case there is no curbing or dwarf wall, then on the Castlederg Line, the above 18 ft. was measured from the end of the sleeper. It is a pity this point seems to have been so decided, for if the carriages be 7 ft. wide then the sleepers being 6 ft. long, the carriages will project

6 in. beyond the sleepers at each side, thus narrowing the width of the road. The form of rail has to be approved of by the County Surveyor. In placing the line the promoters are required to lay the tramway in such part of the street or high road as the County Surveyor shall direct; level crossings are to be constructed to his satisfaction. Before opening the line for traffic the promoters are to erect and complete all new fences, railings, and walls, and to strengthen, improve, and alter all such existing fences, railings and walls, as the County Surveyor shall consider necessary to make the tramway, or road, or street, in or along which the tramway shall be laid safe for the use of the public. There are many other matters including the arbitration as to the amount of the guarantee to be paid at any time which come within the Surveyor's duties, but the above are referred to only to give a rough outline of them; in fact he is, to a great extent, responsible for the construction of the line, and its effect upon existing works, and that without being given anything like adequate and immediate control over the design, construction, or payment for the works; in the latter case he has no power at all.

Where a tramway is projected through any county, the County Surveyor must report on the undertaking to the Grand Jury, and a copy of this report must be lodged with the promoters of the line at least three clear days before the enquiry by the Grand Jury into the undertaking. It is well for the Surveyor when lodging this report to get a receipt. In the case of the above line it was done, and it proved most fortunate that this precaution had been taken.

The report should approximately deal with the project in a financial as well as an engineering point of view, the estimate for the construction should also be considered. In a report on this tramway in 1884, the author pointed out that the con-

struction of the line along the public road without any kind of fencing between it and the public road would be a source of danger, and that for this and other reasons a light railway independent of the public road would be much better. The break of the gauge is also a disadvantage. It was suggested that there should be a clear space of 2 ft. 6 in. between the extremity of the cars when on the rails and the nearest fencing, or in case of no fencing then 12 in. between the same, and the outer edge of the curbing bounding the tramway. None of these provisions were, however, incorporated into the Order in Council.

A rough estimate of the traffic which might be counted on was formed from returns obtained from the railway stations supplying goods to the districts which would be served by the tramway, as well as a rough approximation to the number of passengers going to markets, fairs, &c., including commercial travellers at present using cars from hotels. To this was added a percentage for increase of traffic due to the construction of the tramway itself, and in this manner an estimate was formed of what traffic might be expected. The next step was to form an estimate of the working expenses of which the following is a copy:—

	a.	d.
Traffic - - - -	0	5.56
Locomotive - - - -	0	4.89
Permanent Way - - - -	0	3.53
Carriages and Waggon	0	1.13
General Charges - - - -	0	2.16
Compensation for Loss and Damages of		
Goods - - - -	0	0.03
Rates and Taxes - - - -	0	0.34
Repairs and Renewals - - - -	0	1.50
<b>Total per train mile</b> - - - -	<b>1</b>	<b>7.14</b>

Thus taking three trains per day both ways on 313 days, we have 17,606 train miles making a total of £1,404 a year for No. 2 Tramway; it may be here mentioned that the working expenses at that time on the Ballymena and Larne Railway was 1s. 8d. per train mile. The next step was to form an estimate of the cost of construction for that portion of the line passing through this county—a copy of which is given below:—

Tons	Cubic Yds.	Rate	Length—9 miles, 3 furlongs; Gauge, 3 feet; Slopes, $1\frac{1}{2}$ to 1; Base, 11 feet.	£ s. d.	£ s. d.
<b>ESTIMATE PER MILE.</b>					
	18,320	1/-	5 feet Cutting ...	916 0 0	
	640 per.	5/-	Fencing ...	160 0 0	
	1,662	3/-	Ballast ...	249 6 0	
	1,173	3/6	Road Metal ...	205 5 6	
		30/-	Pipes and Gulleys, 60 yds. ...	90 0 0	
			Retaining Walls ...	50 0 0	
			Bridges, £2,070 ...	230 0 0	
63	—	—	Rail, 40 lbs. Steel, £5 10s. ...	—	346 10 0
2 $\frac{1}{2}$	—	—	Fish Plates ...	—	12 7 6
2 $\frac{1}{2}$	—	—	Fastenings, at £9 10s. ...	—	26 2 6
	2,000	—	Sleepers at 3s. each, ...	—	
			Creosoted ...	—	300 0 0
	141	—	Carriage and Laying of ...	—	
			Material ...	—	7 1 0
			Temporary Accommoda- tion Works ...	20 0 0	
			Land, $3\frac{1}{2}$ acres at £100 ...	350 0 0	
			Stations and Platforms ...	80 0 0	
	28	10	Pavements for Level Cros- sings, in all 13 of them, at 28 sup. yds. each, or about per crossing, &c. ...	21 0 0	
	140	1	Excavation Road Metal ...	7 0 0	
			Rolling Stock ...	700 0 0	
			Proportion to Signals ...	80 0 0	
	1,760 linear yds.	—	Laying, Watching, and Lighting 1,760 linear yards, and maintaining for six months ...	182 0 0	
				3,290 11 6	692 1 0
			<b>Total per mile ...</b>	<b>£3,982 12 6</b>	

This made a total estimate on 9 miles 3 furlongs of £37,337 2s. 2d., which is about the length of the line passing through this county, of which about 5 miles are on the side of the public road, and will, as a rule, be laid about 8 inches above the level of the road—except in fillings, in which case the space for the tramway is banked up, having a retaining wall at the roadside—the base for the tramway at the level of the rails being about 8 feet to 9 feet wide; the width of the carriages, to be used on the line, about 7 feet; the inclines vary from about 1 in 1,300 to 1 in 30; the following is a list of some of the gradients with approximate length:—

Gradients		Length of Gradient in feet
1 in 30	along public road	290
1 in 31	„ „	155
1 in 35	„ „	290
1 in 37	„ „	350
1 in 40	„ „	325
1 in 47	„ „	270
1 in 50	„ „	550
1 in 54	„ „	355
1 in 60	„ „	300
1 in 64	„ „	265
1 in 90	„ „	90
1 in 100	„ „	350

In one place there is a descent of 1 in 30 for about 740 feet long, followed by a horizontal space of about 140 feet, and followed by a rise of 1 in 30 for about 275 feet long. The cuttings and fillings are as light as possible. The quickest curve has a radius of 4 chains. It is to be feared the effect of the steep gradients and quick curves will be felt in the maintenance of the line and rolling stock.

The cross section of the line depends on the position of the level of the rails, as compared with the surface of the road, and may be considered under four typical sections.

First, that in which the level of the rail is about 4 in. above that of the road, and where there is no curbing used to bound the tramway. The road is left 18 ft. wide, as before stated, to the end of the sleeper; the formation level of the tramway is 8 ft. wide; the tramway is formed of a rough paving or pitching of large broken stones, about 6 in. deep, laid with their larger or flat ends down; this pitching is covered with 4 in. deep of ballasting, composed of good, clean gravel or of stone broken to pass through a two-inch ring. On this the sleepers are laid, and the whole space then made up, as in Fig. 12, with good boxing material, either of good, clean gravel or of finely broken stone, in this case to be broken to pass through a  $1\frac{1}{2}$  in. ring. The difference between this section and that in the second case, or where the line is about 12 in. above the level of the road, is that a curbstone should be set along the edge of the tramway platform on the roadside. This curbing should be composed of roughly squared stones of  $10'' \times 18''$  deep, by at least 18 in. long to each stone, and it would be better to have such a curbing in all cases where the line is on a raised platform along the side of a public road, the objection to which is the expense. See Fig. 13.

The third case is that of the line in-cutting on the roadside. Here the whole road should be lowered; this is what is being done on the above tramway, the road being re-made 18 ft. wide, with a path of 5 ft. wide in all cases where there was an existing path on the roadside, which gives a width of 23 ft. at the road level, besides the width required for the tramway. See Fig. 14.

The fourth case is that of the line in-filling. In this case the road has not been raised, the filling being only for the tramway, and bounded on the roadside by a retaining wall; the width on the top of this filling at the level of the rails is about 8 ft.; the retaining wall is of dry rubble. The author

will not now enter into a further description of this wall for reasons which render a discussion at present inadvisable. See Fig. 15.

The drainage of both the road and tramway should be specially attended to. The construction of the line on the side of the road interferes with the proper drainage of the road; hence provision for allowing the water to escape under the tramway into the side drain from the tables of the road should be made at frequent intervals; in cuttings, also, where the level of the public road is altered, drains should be constructed in many cases. These drains should run right down the full length of the cutting at the foot of the slope of the bank of the road, sunk about 18 in. under the formation level of the tramway, filled with broken stone to the road level, with a  $\Lambda$  shaped pipe, formed of small flags or stones in the bottom, and discharging through the fence into the side drain. Drains of this kind are specially necessary in a wet county like this.

The crossings are all level crossings, in some cases the surface of the road being raised, and in others the rails laid at the present level of the road. The rails are to be protected by wooden guard rails of Irish oak, bolted by  $\frac{1}{2}$  in. crab bolts to the sleepers, a space of 2 in. being left between the rail and the guard. These guard rails are about  $6'' \times 3''$  in section; no paving setts are to be used, which, in some instances, is a mistake, the space between the rails being made up with Macadam. Fig. 16 is a section of the rail in position on the sleeper. The rails are to be 45 lbs. steel rail, secured to the sleepers with 6-fang bolts,  $\frac{5}{8}$  in. diameter to each rail, and spiked to the rest of the sleepers by  $\frac{5}{8}$  in. spikes, notched at their ends. The sleepers are cross sleepers of the usual kind used on railways, 6 ft. long by  $8'' \times 4''$  section, grooved for the rails. The joints of the rails are fish-joints, secured by four  $\frac{3}{4}$  in. diameter bolts, with washers; the holes for these bolts in the rail are  $1'' \times 1\frac{1}{8}''$  long.



The bridges are, for the most part, small, and in this county are of stone; they are very narrow where the line is not on the public road. The two principal bridges in this county are, one over the Maguiresbridge river, the other over the Colebrooke river. The former is built on a slight curve, and is of two spans of 25 ft. each, and only 8 ft. wide between the parapets. The latter is a skew bridge of two arches of 25 ft. span, each on the square and of the same width between the parapets as the former bridge.

The sleepers for the rail are placed about 2 ft. 6 in. apart, centre to centre, but at the joints they are only 1 ft. 10 in. apart from centre to centre. Considering the narrowness of the tramway platform and the effect of vibration, all retaining walls supporting the line ought to be of a substantial kind and ample cross section, and it would be much better they were built in good mortar instead of dry masonry.

Special attention should be paid to the fencing both of the tramway and of the road. Where the tramway is constructed on or near the road, the best kind of fencing is that of a mound-fence, faced on both sides with sods in layers, having a base of 5 ft. 6 in. at the level of the road and a height of 3 ft. 6 in. over the same; planted at back with good thorn-quicks, the top being about 15 in. wide, covered with good grass scraw; the quicks are the better of being planted in a double row with about 8 in. between each plant. Stone outlets should be made through the fences, wherever necessary for drainage purposes.

In all cases the perches referred to in this paper are statute perches. At the end of this paper is given a table of some prices for the years 1869 and 1885. There is some difference between the tramway sections and those designed by the engineer of the line, for the contract under which the line is being constructed.

A table of the comparative cost of the maintenance of

some of the public roads in this county is given. The width stated for the road is that of the carriage way, not that between the fences. This table has been formed from the county books for the years stated, the roads selected being spread as generally as possible over the county.

In considering the quantity of material required for the maintenance of streets in country towns, the following statement which has been obtained from the Borough Surveyor of Enniskillen may be of some interest. Some years ago the fiscal business of the Borough of Enniskillen was separated from the county, and has since been conducted under the management of the Town Commissioners with a surveyor of its own. In the year 1884 there were 1,722 perches of roads in the township, requiring 1,406 tons of limestone to keep them in repair, or an average of 0·82 tons per perch. 755 perches of the above roads form the main streets of Enniskillen taking about three-fourth of the above material to maintain them or 1·4 tons per perch. There are three large markets in the week in this town, and very considerable traffic, and the streets are about 33 ft. wide.

In the table of bridges the author was unable to get the cost of some of the bridges, and the last two designs were not carried out.

The arbitration for the amount which any district guaranteeing a tramway may have to pay at any time will involve a good deal of thought and anxiety on the part of the County Surveyor, and requires him to enter upon a subject quite foreign to his office, namely that of railway accounts, to form an efficient opinion; he must audit the accounts of the company every half year, and see that the moneys which ought to be devoted to a dividend are really given to that purpose, but at the same time money must not be claimed for this purpose at the expense of capital.

As the subject of coming legislation with regard to the

fiscal business of grand juries is at present occupying the attention of many people and has been already approached in a paper before this Institution, and is now occupying the anxious attention of county officers, it is perhaps not out of place shortly to refer to the matter here. Changes, doubtless, will be made, not that they are so much required, but because of the general wish of local taxpayers to have complete management of all local affairs. The present contract system and management of fiscal affairs by grand juries has, on the whole, been satisfactory, and has been decidedly economical. The contract system for maintaining the public roads in this county has also worked fairly, and the author considers that all public works should, as far as practicable, be carried out by public contract. It would be a misfortune if this system were swept away instead of improved, as it can be, for the author believes that any system similar to a half-contract system, advocated before this Institution, would mean an increase of expense. The probable cost of 1,000 miles of roads under such a system would be about £13,772 a year to maintain, while the same number of miles here under the contract system costs at present £11,250 a year; and it is not to be forgotten that this county is one of the wettest in Ireland, and, therefore, its roads require constant attention and repairs. Besides, even in these times the expense under the present contract system is not here on the increase, as appears from the comparison of the years 1872 and 1885, given before in this paper. Besides any such general half-contract system, as advocated, would materially interfere with the purely engineering duties of the Surveyor, and reduce him to a kind of check clerk; and the sufficiency of the checks indicated by the author referred to is very much to be doubted. In fact an efficient check for such a system would mean a material increase in the cost of supervision. Certain alterations (of which the following are some) would make

the present system far more efficient than that advocated and would work well, but of course in this paper only a few of the changes affecting the working of the contract system can be indicated:—

1st.—That the members of the road sessions be elected independently of the grand jury, and meet once every half-year, say in May and November.

2nd.—That the meetings of the grand jury or county board (if such should be substituted) be once every six months, say in July and January.

3rd.—That no work be directly presented for in the name of the surveyor but in that of the secretary.

4th.—That ten days' notice should be capable of being served by registered letter.

5th.—That the 19th and 20th Vic., cap. 63, sec. 17, be amended, so that one magistrate may be sufficient to adjudicate, with power to fine on the first hearing of summonses.

6th.—That the lowest tender be not necessarily accepted.

7th.—That the amount on which advances can be made for works done be raised from £20 to £40; and,

8th.—That one clear month's notice of intended applications for new works be given to the surveyor instead of 10 days as at present.

## COUNTY FERMANAGH.

*Schedule of Prices with the Cost of Construction of some New Roads.*

Description	Length of Road in stat. per.	Construction Cost of Road	Price in 1869	Price in 1885	Date of Construction	Remarks
Excavation per cub. yd.	—	£ s. d.	£ s. d.	£ s. d.	—	—
Do. partly in water per cub. yd.	—	—	0 1 0	0 1 7	—	—
Rock cutting do.	—	—	1/- to 2/6	2/6 to 3/4	—	—
Road metal do.	—	—	0 3 6	0 6 0	—	—
Rubble masonry do.	—	—	0 10 0	0 14 0	—	—
Arching, string and coping, per cub. yd.	—	—	1 10 0	2 5 0	—	—
Ashlar masonry, per cub. foot	—	—	0 1 7	0 2 3	—	—
Parapets, per cub. foot	—	—	0 0 7	0 1 4	—	—
Dry stone work, per cub. yd.	—	—	0 7 0	0 8 0	—	—
Common Labourers, per day	—	—	1/3 to 1/6	2/- to 2/6	—	Per day
Navvies - -	—	—	0 2 0	2/6 to 3/-	—	Per day
Masons - -	—	—	0 3 4	5/- to 6/-	—	Per day
Cart-horse and man -	—	—	0 4 0	0 6 0	—	Per day
New road - -	224	448 0 0	—	—	1877	16 ft. wide
Do. - -	178	358 0 0	—	—	1877	18 ft. wide
Do. - -	537	1,020 6 0	—	—	1877	18 ft. wide
Do. - -	174	319 10 0	—	—	1878	16 ft. wide
Do. - -	368	669 0 0	—	—	1879	16 ft. wide
Do. - -	149	223 0 0	—	—	1880	16 ft. wide
Do. - -	188	357 4 0	—	—	1885	16 ft. wide
Do. - -	383	928 15 6	—	—	1885	16 ft. wide

*Comparative Cost of Maintenance of some Public Roads under 5 years' Contract System in Co. Fermanagh.*

Description	Width of Carriageway in 1866	Width of Carriageway in 1867	Length in Statute Perches	Annual Cost per Perch in 1866	Annual Cost per Perch in 1867	Annual Cost per Perch in 1868	Width of Carriageway in 1865
	Ft.	Ft.	Pchs.	s. d.	s. d.	s. d.	Ft.
Mail Coach road -	32	32	686	1 11	2 4	0 10½	18
Main road - -	21	21	480	—	1 3	1 0	20
Cross Country road -	10	10	462	0 6	0 7½	0 8	12
Main Market road -	14	14	869	0 6½	0 8	0 10½	16
Main Post road -	18	18	794	1 2½	1 0	0 9½	18
Main Post road -	18	18	684	2 0	1 9	1 0½	18
Main Market road -	18	18	980	1 6	2 2	4 0	21
Main Market road -	18	18	505	1 10½	1 11½	1 7½	18
Main road - -	16	16	1,076	0 8½	0 10	0 9	16
Main (Gravel) road -	16	16	970	0 9½	0 8	0 8	16
Main (Gravel) road -	14	14	1,012	0 3	0 4½	0 1½	16
Cross Country road -	14	14	561	0 7	1 1½	0 5½	16
Main road - -	18	18	1,089	1 5½	0 8½	0 3	18
Main road - -	21	14-21	667	0 8½	0 9	0 7½	16
Post road - -	14	14	560	0 6½	1 0	0 5	18
Cross Country road -	16	16	1,086	0 5	0 3½	0 3	14
Country road - -	18	18	584	0 6	0 5½	0 7	18
Country road - -	16	16	603	0 9	0 11	0 10	14-16
Main road - -	32	32	905	1 2	2 4	1 4½	18
Country road - -	16	16	706	0 8	0 8	0 4	14
Post road - -	21	21	1,052	1 4	2 4	1 6	21
Post road - -	21	21	1,310	1 4	1 5½	1 6	18
Main road - -	32	32	862	1 11½	2 10	1 2	18
Main Post road -	21	21	344	2 5½	2 5	1 9	18
Average - -	19' 0"	18' 9"	—	1 0½	1 3½	0 11½	17 nearly

In considering the above the increase of prices should be included.

*Principal Dimensions of some Bridges constructed in Co. Fermanagh.*

Name	No. of Spans		Span		Rise		Height of Abutments to springing		Thickness of Abutments at springing		Thickness of Pier at springing		Length of Parapets		Depth of Key		Depth of Arch at springing		Alternate Lengths of string on Soffit		Cost		Remarks
	No.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	£	s.	
Killyclogher	-	1	18 0	6 0	8 0	4 0	—	—	—	—	—	—	40 0	1 6	1 6	1 6	1 6	1 6	2 3	2 3	200	0	A skew bridge, in 10 ft. of filling, on a very soft foundation.
Loughill	-	1	12 0	3 0	4 6	3 6	—	—	—	—	—	—	22 0	1 6	1 6	1 6	1 6	1 6	2 6	2 6	120	0	Square bridge, in filling.
Moughly	-	1	20 0	5 0	6 0	5 6	—	—	—	—	—	—	44 0	1 6	1 6	1 6	1 6	1 6	2 6	2 6	259	0	Do. partly in filling.
Drumhemuck	-	1	15 0	3 6	7 0	4 0	—	—	—	—	—	—	34 0	1 6	1 6	1 6	1 6	1 6	2 6	2 6	178	10	Skew bridge, in good ground.
Cush	-	1	10 0	3 0	5 0	3 0	—	—	—	—	—	—	25 0	1 3	1 3	1 3	1 3	1 3	2 3	2 3	96	10	Square bridge, in firm ground.
Montaghrow	-	1	10 0	5 0	6 0	4 0	—	—	—	—	—	—	22 0	1 6	1 6	1 6	1 6	1 6	2 6	2 6	220	0	Do. do. including approaches to bridge.
Drumane	-	2	30 0	7 6	8 0	3 0	5 0	115 0	1 9	1 9	1 9	1 9	77 0	2 0	2 0	2 0	2 0	2 0	2 9	2 9	1,500	0	Square bridge on very soft foundation, on piles, in filling.
Bannagh	-	1	30 0	10 0	10 0	7 0	—	—	—	—	—	—	77 0	2 0	2 0	2 0	2 0	2 0	2 9	2 9	500	0	Square bridge, in 19 ft. of filling built in 1871.
Carrick	-	1	25 0	5 0	10 0	4 6	—	—	—	—	—	—	50 0	1 6	1 6	1 6	1 6	1 6	—	—	—	—	Square, in 7 ft. filling.
Rosalea	-	1	32 0	8 0	8 6	7 6	—	—	—	—	—	—	77 0	2 0	2 0	2 0	2 0	2 0	2 9	2 9	392	0	Do. in 15 ft. filling; built in 1866.
Tullyrain	-	1	10 0	5 0	18 0	4 6	—	—	—	—	—	—	60 0	1 6	1 6	1 6	1 6	1 6	2 3	2 3	—	—	Do. in 18 ft. filling, between firm banks.
Garrison	-	1	40 0	8 0	8 0	8 0	—	—	—	—	—	—	64 0	1 9	2 3	1 9	2 3	1 9	3 0	3 0	349	0	Built in 1846.
Tempo	-	1	35 0	7 0	10 0	7 0	—	—	—	—	—	—	75 0	1 6	2 0	2 0	2 0	2 0	3 0	3 0	—	—	Elliptical, in deep filling.
Black River bridge	-	1	35 0	9 0	8 0	3 0	—	—	—	—	—	—	76 0	2 0	2 0	2 0	2 0	2 3	3 5	3 5	489	0	Skew, in 15 ft. filling.
Tullyreagh	-	3	22 0	7 6	14 0	5 0	3 6	113 0	1 9	1 9	1 9	1 9	76 0	1 9	1 9	1 9	1 9	1 9	2 6	2 6	600	0	Square bridge, in 12 ft. of filling.
Meenatully	-	1	14 0	7 0	21 0	3 6	—	—	—	—	—	—	50 0	1 6	1 6	1 6	1 6	1 6	2 6	2 6	—	—	Square bridge, in 26 ft. filling.
Drumane	-	3	22 8	4 6	13 0	5 0	8 9	143 0	1 10	1 10	1 10	1 10	143 0	1 10	1 10	1 10	1 10	1 9	2 9	2 9	—	—	Designed but not built, estimate £1,200. In 1874 above bridge built instead.
Banlackillen	-	8	30 0	15 0	21 0	5 6	4 6	448 0	2 6	2 6	2 6	2 6	448 0	2 6	2 6	2 6	2 6	2 6	—	—	—	—	Designed but not built; £2,000 presented for its construction in 1866.

Mr. WHITE said—Mr. Willson had referred to many matters of importance connected with county work in Ireland, and his paper will be read with much advantage by intending candidates for county surveyorships.

With regard to the most suitable materials for road metalling, the igneous rocks supply the toughest and best to resist heavy traffic, such as the close grained granites and syenites, basalt, and the transition or gray wacké of Penmaenmawr—the latter material, after 20 years' use in streets of Manchester, is said scarcely to have shown signs of wear. He remembered some years ago, when connected with the Corporation of Kingston-upon-Thames, they found it more economical, after trying both, to maintain the roads in that neighbourhood with Cornish granite than with the local chalk flints—the former material costing about 18s. per ton, and the flint only about 3s. 6d. per cubic yard; and although many of the Co. Dublin and Wicklow granites appear coarse grained and soft, yet it would appear probable, after due investigation, that granite quarries might be opened more suited for metropolitan roads and streets than the local limestones.

Good limestone, however, adapted for country roads, is almost universal in Ireland. In the case of the harder rocks, not easily broken by hand, some information as to what has been done by machinery would be very useful. The stones should be broken early in the season, fresh from the quarries, when they are often soft, and be allowed time to harden before application to roads.

With regard to bridge repairs, he successfully tried the remedy for split arches, touched on by Mr. Willson, in a large old bridge of great importance some years ago. The tie-rods were heated before being screwed up, and when the outer bars, inserted into grooves cut into rings, were cemented over, their existence was not noticeable.

With regard to construction of large bridges, piers, retain-



ing walls, &c., it is much to be regretted that, according to the present contract system, there is no provision under the Act to nominate clerks of works; it is impossible for county surveyors or their assistants from occasional visits during progress to duly examine such buildings. He very recently inspected the retaining wall of a large bridge just fallen not many years built, and could not help thinking it was bad economy to have no means of insuring due supervision during its erection.

With regard to tramways, with many others he had to enter very fully into the subject two years ago. There were seven schemes put forward in the Queen's County; there was much in favour of Mr. Willson's remark, that had the Treasury contributed the whole guarantee in the first instance, and then made the baronies or districts contribute in proportion, funds would have been easier obtained.

As to the gauge, 3 feet, selected for the Clogher Valley Line, and to his statement that a light railway full gauge would have suited better, this may be so; but, as a general principle, the House of Lords' Select Committee went very fully into the whole matter in 1879, and decided on the narrow gauge.\*

The great point as to the probability of tramways ever being generally constructed in Ireland—that is when things settle—is, would they pay? He believed they would, in many cases, and well, as the traffic became developed. If we assume a parallel between these tramways and French secondary railways, the ministerial inquiry in 1878 deduced from a series of observations applying only to lines earning under £10 per week per mile the following formula in English measures, referred to during discussion on the valuable paper by Mr. Green in 1881, before this Institution:—Working expenses per mile per week = £2 10s. +  $\frac{1}{3}$  (weekly receipts). Assum-

\* See Evidence of Mr. Althorp, General Manager of Midland; Mr. Oakley, of Great Northern; Mr. Small, of London Tramways, and many others.

ing its substantial accuracy, a tramway or line of this class paying no dividend, but just self-supporting, should earn £3 15s. per mile per week ; and the following statement can be deduced :—In order to be a financial success, the gross annual receipts should equal £195 multiplied by the mileage, added to one and a half times the annual sum required to be paid as interest.

Referring to proposed changes in the law, he could barely admit that the contract system for roads has, on the whole, been satisfactory, especially for main roads. He considered that for the normal expenditure presented at present, far better results would be attained under better universal regulations, and, without entering into matters before discussed, a few further observations on this important subject appeared necessary.

One of the difficulties connected with a maintenance labour system for a term of years would be more easily understood by a simple illustration stating a case exactly similar, and presenting the same difficulties. Let a contractor under a legal instrument be assumed to bind himself to supply the street lamps of a country town for five years as required, with oil, lights, and labour—suppose the contractor fails at various periods to fulfill his contract, the law, we will assume, requires him to be served with notice to fulfil his contract from time to time—if he complies, unless he could be fined by deducting from the amount of his tender, which practice is not generally followed in most counties for roads, it would appear that as he has always fulfilled his contract when required, he would be entitled to payment consequently at the end of the term. The real remedy here would be to take the lamps off his hands after the first neglect, and prosecute him for any loss, or institute fines. Future attention can never atone for previous neglect—the parallel is exactly the same in the case of roads.

Next he would observe that under the half contract system the expenditure, after the first year or two, could be largely

reduced; the roads becoming better, would be easier kept, and require less material—that he knew from experience. The difficulty—a real one—pointed out by Mr. Willson, with regard to the labour of checking the pay sheets, could be obviated by getting them checked for each district by assistants, signing instead one list weekly, containing the amounts, opposite to each number, corresponding to the pay sheets.

However, it must be clearly remembered that the author of the paper referred to never committed himself to requiring, as being in his opinion essential to reform, the universal adoption of the half contract system. What he advocated was that County Boards or Grand Juries should be authorised to have roads thus maintained, instead of necessarily being compelled to have them all done by contract as at present, unless there are no proper tenders put in.

In his opinion the best remedy for existing evils (in addition to others indicated) would be, either to have all maintained on half contract system, or to have a fixed proportion of main road, say one-fourth to one-third of the mileage, in each county scheduled off, which should be constantly kept up in the manner indicated. He spoke from actual knowledge when he stated that the effect of this arrangement among the surrounding contractors would be enormous. Immediately, without any trouble, their standard of work would be raised owing to the competition of systems established, taken together with the very material fact that skilled overseers would be always there available on the spot, to take up defaulters' roads and repair them with a trained staff of men economically, which cannot be done at present in most counties. There is no doubt that the contract system for maintenance labour, if it could be enforced, possesses several advantages, which for practical purposes could thus be sufficiently utilised to give good results. As to the difficulty experienced about contractors' bonds for a term of years, which has an objectionable legal bearing in addition to these

pointed out, this might be remedied by having them made out for double the amount for the full term of years between the actual tender and the estimated cost of the work, as under proper regulations the actual money presented could always be made immediately available for cash payments to workmen in case it became necessary to take a road off the contractor's hands.

The reason doubt was expressed as to being able successfully to carry out the "double system" for maintenance of roads—namely, the contract and half contract—simultaneously, is that it is believed, owing to the contractor's influence with the ratepayers at sessions courts, it would often be very hard to get the main roads scheduled as suggested, particularly as under this heading would be included those naturally best paying. All this, however, would be overcome by making the scheduling compulsory as far as necessary in each county or district.

Now, in considering the suggested alternatives—the half contract system applied universally or partially—possibly, on the whole, the balance of evidence would be in favour of the latter applied to scheduled roads, as the change would remedy most of the existing evils, and involve but slight alteration in present arrangements to begin with, either as regards cost or modes of procedure, and would ultimately prove much more economical and efficient than the present contract system, which he believed, standing by itself, could never, from its very nature, by any suggested improvements be made satisfactory. Of course it is to be understood, from the ideas expressed, that it is proposed to substitute cash payments to a large extent, for all kinds of county work, for the long-credit fiscal arrangements existing in most counties. This can be done by proper management everywhere in Ireland, and will be found intimately connected with any proposed scheme of reform.

Mr. J. H. MOORE remarked that while not insisting rigidly on the 16 feet limit, he would endeavour to widen the road to at least 14 or 15 feet by cutting away backs of fences, &c.; and subsequently, if the traffic warranted the outlay, get special presentments to widen narrow places. The carriageway he generally made 10 feet wide. It was difficult to get more money allowed than would suffice to fill the ruts and gravel the road—the rates in the county varying from 2s. 6d. to 4s. per perch. But as these roads are not used by the general public, it would be absurd to spend more money on them than suffices to make them fit for carting over. The number of these roads was rapidly increasing, and on an average 10 miles are put on in Meath every year.

In forming bog roads, as far as he could discover, the old roads have no foundation but bog sods and clay, about a foot deep; and he has found that a good layer of furze and heather, or if procurable, fir branches and thorn bushes, with bog sods and about a foot of clay or clayey gravel, coated six inches deep with coarsely-broken stones and three to four inches of road metal, make a good firm road. The great difficulty with bog roads arises from unequal settlement, as drainage proceeds and the bog gets cut away. It is clearly impossible to fence a bog road with mound fences in the usual way. Fences of bog sods quickly disappear, and if clay and sods are carted to make fences the weight sinks the sides, or in roads across cutaway bogs breaks them away. A good fence can be made with alders if the occupiers can be induced to protect them.

The footpath described is only suited for the vicinity of towns and places where stones and money are abundant. For country roads a sod kerb answers every purpose, and can be kept trimmed and lined. If the path is properly drained and gravelled any firm filling will do for a foundation. The great difficulty in most parts of the country is to get clean gravel.

As to the proposed amendments to the Grand Jury Act,

Mr. Moore agreed with Mr. Willson on Nos. 1 and 2—viz., electing members of sessions and grand jury and half-yearly meetings; but he did not see the object of No. 3—making presentments to secretary instead of surveyor. He also agreed with him as to 4 and 5, especially that magistrates should have power to inflict a fine, the present system being almost unworkable; and also as to No. 6—non-acceptance of lowest tender—but he saw no object in No. 7, as advances are quite optional. As to No. 8, the system of notices is faulty altogether, and various devices are resorted to in different counties to increase the time. In Meath the secretary's clerk goes round about a month before the sessions collecting applications at convenient centres, and very little attention is paid to applications sent in subsequently.

**ON THE MAINTENANCE AND REPAIRS OF COUNTY ROADS  
IN IRELAND. By J. OUSELEY MOYNAN, Member.**

THE greater portion of this paper having been written before the author had seen Mr. White's paper "On the Relation of the Irish Grand Jury Laws to County Works," with a view to having it read, at some future time, before the Institution of Civil Engineers, it occurred to him that the present time would be suitable to bring it forward, so that the existing practices of maintenance and repairs, on different classes of roads, in different counties, might, as far as possible, be compared as regards efficiency and cost, the merits and defects of the various systems discussed, and schemes for improvement suggested.

The subject is one of great importance to the professional engineer, as well as to the community at large, from its extent, necessity, and cost. Having regard to the facts that the total length of Irish roads exceeds 51,000 miles, and the annual cost of repairs is over £650,000, any practical methods of improving the condition of these roads, and, at the same time, by lessening the cost, lowering the rates, must be most beneficial to the country at large. Should the discussion on this paper, by eliciting sound practical suggestions, tend in this direction, the author will feel that it has not been written in vain.

The author proposes to divide this paper into two parts—the first treating of existing systems of repair in the different counties, comparing the result as far as practicable, and also giving an approximate comparison of the cost; the second will contain some suggestions as to alteration of present practice.

## PART I.

It does not come within the scope of this paper to deal with the original construction of roads, but solely with the maintenance and repairs of existing roads, as at present carried on under the various Grand Jury Acts; however, in passing, the remark may be made that, in three cases out of four, the bad condition of many roads through the country may be attributed to, originally, defective formation, but this defective construction will only be dealt with in so far as it may be improved or remedied by repairs executed under maintenance contracts.

All necessary work for road repair may be included under three heads. These will be considered in the following order, which the author considers is that of their importance:—1. Drainage, subsoil and surface; 2. Supply of metalling and method of spreading same; 3. Scraping and cleaning. In most districts the order of importance seems to be considered:—1. Supply of metalling; 2. Scraping and cleaning; 3. Drainage. This is a very serious mistake, and tends more than anything else to excessive cost combined with inferior roads. If the foundation is not kept drained it will be impossible to maintain the working crust in satisfactory order; no matter what amount of metalling may be applied the road will be constantly rutted and covered with mud, so that while the surface is deteriorating the supply of metalling is increasing, and the labour of cleansing much in excess of what it ought to be. There is further the increased danger of the road completely bursting up after, or during, severe frost; this is minimised when the subsoil is maintained in a dry condition. The following extract from a report by Macadam to the Board of Agriculture bears so strongly on this point that it is quoted at length:—

“The roads can never be rendered thus perfectly secure until the following principles be fully understood, admitted, and acted upon—namely, that it is the native soil which really



supports the weight of traffic, that while it is preserved in a dry state it will carry any weight without sinking, and that it does, in fact, carry the road and carriages also; that this native soil must be made quite dry, and a covering impenetrable to rain must then be placed over it, to preserve it in that dry state; that the thickness of a road should only be regulated by the quantity of material necessary to form such impervious covering, and never by any reference to its *own* power of carrying weight. The erroneous opinion so long acted upon, and so tenaciously adhered to, that by placing a large quantity of stone under the road a remedy will be found for the sinking into wet clay or other soft soils—or, in other words, that a road may be made sufficiently strong, *artificially*, to carry heavy carriages, though the subsoil be in a wet state, and by such means to avert the inconveniences of the natural soil receiving water from rain, or other causes, has produced most of the defects of the roads of Great Britain."

As a further illustration of the value of improved drainage, the author may mention that he has been informed by the chief engineer of one of the largest Irish railways that a saving of over £4,000 per annum in the cost of maintaining the permanent way has been effected by simply deepening and improving the drainage system on his line. That a similar good effect must follow from improved road drainage is perfectly evident, as there is little or no risk of subsidence in a dry subsoil, and a dry road surface, when properly made, suffers far less from attrition or disintegration from road traffic than the same surface when constantly wet and muddy. The improvement of the drainage of roads in his charge should, consequently, be the first care of the County Surveyor. His reward will be better roads at much diminished cost.

The author is so impressed with the importance of proper drainage that he will go so far as to say no amount of care or trouble will put a badly drained road into satisfactory order;

further, there is no excuse for bad drainage, the work of preparing a system is so simple and inexpensive compared with the results obtained, and its annual maintenance in proper working order so easy and cheap.

2. Next in importance to efficient drainage is the supplying and spreading of the metalling or material intended to maintain the working crust at a sufficient thickness. The consideration of this question involves several subjects, such as the geological and physical feature of the counties, the relative value of the different kinds of stone for road traffic, the different methods of supplying in the various counties, the best size of stone, and the method and proper time for spreading.

As regards the geological features of the country, it may be briefly stated that about two-thirds of the surface is on limestone formations; the great bulk of this being carboniferous limestone, comprising the greater portions of the following counties:—Fermanagh, Sligo, Leitrim, Mayo, Roscommon, Longford, Galway, Westmeath, Meath, King's County, Kildare, Dublin, Clare, Tipperary, Queen's County, Limerick, Cork, and Kilkenny, and about half of Monaghan, Kerry, and Waterford. The Silurian and Cambrian strata, consisting of clayey slates alternating with hard felstones and other igneous rocks, predominate in the counties Donegal, Londonderry, Tyrone, Down, Armagh, Cavan, Louth, and Wexford, and occupy half of Wicklow, Waterford, and Kerry. They are also well developed in the western parts of Galway and Mayo, and in East Wicklow and North Longford. Trap and felstone constitute about nine-tenths of Antrim and one-third of Londonderry. The cretaceous formation is also prevalent in these districts. The greater part of Carlow, half Wicklow, and considerable portions of Down, North-west Donegal, and West Galway, are on a granite formation. The old red sandstone is well developed in parts of Waterford and Cork.

Summarising roughly, it may be stated that the roads in about twelve-twentieths of Ireland are repaired with different qualities of limestone; in about three-twentieths with clayey slate and old red sandstone belonging to Silurian and Cambrian date; in about two-twentieths with hard felstones and traps of similar date; in about one-twentieth with Eocene traps and lavas; in about one-twentieth with granite, hard and soft; and in about one-twentieth with other material impossible to classify.

In addition to considering the substrata or geology of the districts, we have to look to its physical features; and, in doing so, we reach the conclusion that of the entire surface of Ireland there is one part waste bog, mountain, and water, to four parts agricultural land, the exact number of acres being as follows:—

	Acres.
Agricultural land . .	15,604,180
Waste bog, mountain, &c. .	4,590,422
Water . . . .	625,326
Total .	<hr/> 20,819,928

This indicates roughly the nature of the subsoil, whereas the geological features roughly show the class of material available for the repair of the roads.

The author has not been able to get reliable returns from the different counties of the proportion of bog roads, or those having a spongy bad foundation, to those having a firm or fairly good foundation; but, so far as he has got these returns, the proportion seems to be somewhat as these figures would indicate, or that they are in the proportion of 1 to 3½.

In reply to queries as to best class of stone for general repairs the answer has, almost invariably, been a good hard limestone. A good whinstone or flint is also reported as being a very serviceable material, but there is great difficulty

in getting it broken small enough, and moreover it is apt to break into sharp particles, likely to cut and injure horses' feet; hard granite is reported favourably on, and so are some grits, but the vast preponderance of opinion seems to be in favour of the limestone, both on account of the extent of the formation and the practical results obtained from its use. The worst materials are soft friable granites and sandstones, and the shaley slates so common in many parts of Ireland. Intermediate between good broken stone and bad slates comes the limestone gravel, which makes a fairly good road, excellent for light traffic, but unsuited to heavy.

The method of supplying stone varies considerably throughout the country, some counties requiring all stone to be measured before spreading; others dispense with measurement, and only require the roads to be maintained in proper order, stone being prepared and spread according as it may be required; a third method is that of requiring a certain number of perches of the road to be coated, full width, each year. A combination of the first and second method appears to be the most common—namely, measuring the quantity for the more important roads, and maintaining the remainder without measurement. All these schemes appear to have some advantages and corresponding disadvantages. Some of both may be mentioned:—1. Where the quantity is specified and measured it insures that a certain amount of material, which experience has shown to be the average amount required to keep the road in repair, has been supplied and spread—a good method, no doubt, for average years, but failing to give satisfactory results in either exceptionally dry or wet seasons (moreover, it necessitates the spreading of the great bulk of the material in a couple of months—a practice which the author does not consider good, and which he will deal with hereafter). In the first case the quantity is excessive; it makes the road very rough and unpleasant to travel on if

spread, and is a positive injury to the road, since the stones will not bond, but travel over the surface and wear it down. Should the material be not spread it accumulates on the roadside, and next year the contractor receives his money for work undone. This might be of little consequence did dry and wet seasons alternate. Such, however, is not the case, as they appear to follow one another in series, and if the quantity required for a wet season be put out and spread during a succession of dry years the road becomes "hog-backed," so that, all the traffic going along crown, it becomes rutted and uneven, and the road being too high at centre makes it dangerous to travel along the side on account of the great side slope. The converse difficulty may occur in a succession of wet seasons. It is practically impossible to reserve the surplus from dry years to augment the deficiency in wet ones, and also, if a pronouncement of Baron Dowse, at Longford Summer Assize, 1884, be good law, illegal. In this case the author, recognising the disadvantages of strictly adhering to the contract quantity, wished to introduce a modification of the system, by diminishing the quantities in years not requiring the full amount, and causing the contractor to put out the balance when required. Unfortunately the Secretary of the Grand Jury, in the case of these contracts, introduced the word "about" into the schedule, so that the presentment read—"To                      to repair                      perches of the road from  
to                      (about                      cwt. broken stone per  
perch)." Baron Dowse refused to fiat these presentments, and said "he recognised only two forms of road contract—one to keep it maintained, without specifying any quantity of material, the other having the amount specified, and in this case the contract must be strictly carried out, as he would allow no power to any County Surveyor to vary from the terms of the contract." This may or may not be the strict law, but if it be, it would appear to absolve the contractor

from the liability of having to put out extra material during very wet seasons, and might cause great inconvenience.

Another serious disadvantage of quantity roads is the liability of fraud on the part of contractors, such as spreading heaps deceitfully made up, the centre being filled with road scrapings, &c., removing the material, after it has been measured on one road, to another road for fresh measurement; and in counties where the maintenance and contract systems are combined, using the measured stone on the maintained roads. These and many other forms of fraud are extensively carried on; they are very difficult to detect, and hard to punish properly.

The unsightly heap of broken stone along the roadside interfering with the drainage and spoiling the grass margins are another disadvantage of this system. These heaps cannot be dispensed with without forming expensive receptacles at frequent intervals along the roads.

The system of maintaining without measurements obviates most of these inconveniences, but it is not suited to roads of heavy traffic, though very well adapted to roads of light traffic. It requires very strict supervision to prevent the contractor "starving" the road by not supplying sufficient material to maintain the crust in working order. In this case the road may seem to be in very good order, but it gets thinner every year, and at last getting completely worn out requires a very heavy outlay to again renew it. This case is very common and must continue to occur under the existing contract system, where the sole idea of the contractor is first to get the job at any price so long as he can keep his neighbour out of it, and, having got it, by doing little or nothing to make some money at the expense of the county.

The third system—*i.e.*, that of coating, full width, a certain number of perches of the road each year, apparently meets the difficulty of insuring a sufficient quantity of metalling, and, at the same time, doing away with the disadvantages of

both other methods; however, it has either, or both, of two very serious drawbacks—1. If the stone is spread off at once and an account of the number of perches coated taken, the road must be sheeted in very large patches—a practice objectionable in itself, causing long lines of ruts and uneven and unpleasant roads; it requires a large staff of assistants to see that the work is actually done, and there is no sufficient reserve of stone to fall back on in case of emergency. If the stone be spread from time to time as required, it would be utterly impossible to keep account of what has been done, and consequently impossible to insure of the proper quantity being spread.

The foregoing appear to be the principal systems adopted in Irish counties for the supplying of the road metalling; the first is in vogue in twelve counties, the second in three, the third in six, and a combination of the first and second in ten counties. The preponderance of opinion is thus shown to be decidedly in favour of combining the first and second method—namely, measuring a specified quantity of metalling on main, or heavy traffic, roads, and maintenance contracts on the less important roads. This certainly appears to be the best arrangement possible under the existing contract system—a system which has so many serious defects, it is a source of wonder to the author that, up to the present, it has given such fairly good results. Three of the worst defects are—1. It is almost compulsory, if the security offered be considered good, to accept the lowest tender, even if the price is far too low to execute the needful work, or the proposed contractor utterly ignorant of the work required, or even if he be a known bad contractor. 2. The difficulty of obtaining a proper remedy against defaulting contractors. 3. The length of time contractors have to remain without payment, meantime carrying on the work at his own expense; this time amounting to fully eight months in the winter.

The first two defects seriously affect the cesspayer; the

third is an undoubted hardship on the contractor, and is, indirectly, injurious to the cesspayer also, as it often happens that the contractor, being unable to raise money, has, through want of funds, to neglect the road. This entire subject has been exhaustively dealt with by Mr. White in his paper before referred to, and is only referred to here that the author may say that, in his opinion, if the contract system is to be continued, a radical amendment of these and other defects must very soon be effected.

In connection with the supply of metalling, the proper size of the broken stone, and the best method of spreading same, are matters of great importance. First, as regards the best size. In most Irish counties the stones are specified not to exceed 2 inches in largest dimensions. Some County Surveyors specify  $1\frac{1}{2}$  inches, and one or two 1 inch as largest size. It is a matter of notoriety that it is almost impossible to get contractors to break stones even as small as 2 inches, and that the general average through the country is nearer to 3 or  $3\frac{1}{2}$  inches than to 2. It is hard to understand why this should be so, for any contractor ought to understand that a cube yard of stone broken to 2-inch diameter will cover much more road surface than if broken to 3-inch diameter; thus, a cube yard of stone broken to  $1\frac{1}{2}$ -inch diameter will cover from 28 to 30 square yards of road surface, but only about 14 or 15 if broken to 3-inch diameter. The question still remains—What is the best size? The answer is, no stone should exceed 2 inches. Anything larger is injurious to the road, and breaking smaller a needless expenditure of labour. There are very few country roads which require a greater amount of metalling than is sufficient to coat them 1 inch thick every year. By having the stone broken to 2-inch diameter such roads can be completely coated 2 inches deep every two years, or at the rate of 1 inch each year. Moreover, smaller stones bond better than large ones, which are liable to be



disturbed, both by horses feet and by the wheels, while the smaller size are beaten down and bond together, forming a smooth even surface, very agreeable to travel on.

As regards the spreading of the stone, it should only be put on when and as required. The present practice of spreading off large quantities of stone during a couple of winter months is not a good or economic one. It makes all roads very rough and unpleasant to travel on, and also encourages neglect on part of contractor, who imagines that, having done what he considers the principal work of the year, he may then leave the road to itself, and quietly wait until the assize for his money. The spreading of the metalling should be a continuous operation, lasting the entire winter and through wet periods in summer. The amount spread should be in exact proportion to the requirements. The stone should be spread in good sized patches, not too small—this causes vehicles to bump and wear holes in road; not too large—this induces the vehicles to go in lines and forms ruts; but spread in patches varying from  $1\frac{1}{2}$  square yards to 9 square yards in area, and placed at alternate sides of road, to cause traffic to beat across the entire surface.

The third great division of road repair—scraping and cleaning—though very important, can be very briefly considered. It is generally looked upon by the contractor as unnecessary, and, consequently, partially neglected, or else very badly done. Their great difficulty seems to be not so much the scraping of surface as the removal of the mud, which is far too frequently placed on the margin, and allowed to accumulate in large heaps, draining back on to road, and softening and injuring surface. Cleaning roads, to be practically useful, must be constantly attended to, the road scraped according as mud forms, and the scrapings at once removed. By attention to this work, the formation of ruts is prevented, and a great saving of material effected.

## PART II.—SUGGESTED ALTERATIONS OF PRESENT PRACTICE.

Before entering on the discussion of the second part of this paper the author wishes it to be distinctly understood that he is not advocating any method in particular, but merely stating what has been already proposed, in the hopes that a definite opinion may be elicited, during the discussion, as to what is really the most suitable method of carrying on the maintenance of Irish roads in the future, having regard to the certainty that new legislation on the subject will be enacted in the near future, and that such legislation will intimately affect both the existing practice and also the County Surveyors, who should now, unitedly, put forth their views and endeavour, as far as they are able, to direct the Legislature to the best advantage.

Three suggestions have been made, as follows:—

1. Continue the present contract system, with such modifications as may be necessary to insure due observance of the terms of their contracts on the part of the new contractors, and also to prevent the contractors having to be so long out of their money as at present.

2. The doing away with the contract system altogether, and substituting therefor a system of paid labour with proper supervision, the entire work being under the command of the County Surveyor.

3. That a paid staff shall carry on the work of cleansing, repairing, and trimming the roads, and that the metalling shall be supplied and distributed by contract.

A few remarks on each of these proposals will close this paper.

As regards No. 1. There can be no doubt that, while it has many defects, the existing contract system has, up to the present, answered its purpose fairly well, and that under it the

county roads have been tolerably well, and economically, maintained. Most of its defects have been already pointed out. These could easily be remedied, and the system made more efficient than ever by enacting that it be quite discretionary with the authorities to accept or refuse any tender. By this means known bad, or defaulting, contractors would be excluded, and contracts would not be set at the absurdly low figure which many are taken at now. Also more summary methods should be provided for the punishment of defaulting contractors—such as a fine for first offence, and total loss of contract with recovery of substantial damages from self and securities for second. The damages should be recoverable at petty sessions, and should be available for the immediate repairs of the road, or a fund for the purpose of repair should be provided, and the damages recovered at the next quarter sessions. Attempts at fraud, such as making up heaps of stone with the centre filled with road scrapings, or removing stone from one road to another when it has been measured for the first road, should be made criminal offences, and punishable with imprisonment. Further, the authorities should be empowered to deduct from the contract amount for any neglect to carry out portions of the work, instead of, as at present, either giving all or none—the first being unfair to the ratepayers, the second being often more unfair to the contractor.

Payments, especially on large contracts, should be made more frequently than at intervals of four and eight months—say, once a month or once every two months.

If the above and some other modifications were made every little minutiae of the contract could be insisted on, or corresponding deductions made in the amount of the contract, and the neglected work carried out at the contractor's expense. This would very soon stop neglect, and a few criminal prosecutions would soon stop fraud.

This system properly amended would, probably, be the most efficient and least troublesome that could be adopted, and also very economic. The average rate per mile through Ireland under the existing contract system is about £12 10s., as shown in the table of statistics; this would be very likely increased under proposed modifications, but not very much, while, without doubt, a vast improvement would soon be visible in the roads.

As regards No. 2. This proposal involves a radical change of all existing arrangements, the doing away with contractors and the substituting therefor a large staff of labourers and overseers scattered all over the country. Any consideration of this scheme must be purely empirical, as it is not in existence in any part of Ireland; but at first sight the following difficulties show themselves:—Paid labour without adequate supervision is certain to be very expensive, as the labourer endeavours to do as little as possible for his money; also there is the certainty of a great deal of fraud in such a system of small gangs of labourers scattered all over the county, pay sheets coming in for men who have not worked, or who, if they have made a show of working, have done absolutely nothing. Without supervision there appears the danger of deterioration from neglect, and even with supervision there is danger of the rates rising from increased expense.

Supposing it possible that such a system should be made law, the author employed some leisure time in endeavouring to make out a scheme for the County Longford, in order to see if it could be carried out, and, if possible, to ascertain the expense. The following is an outline of this scheme:—

First, divide the county up into districts, each having about 20 miles of roads; the proportion of main roads to second-rate roads being about 1 to 4, there would, in these districts, be about 5 miles of main, or first-class, roads to 14 miles minor roads. To keep each of these districts in good order would require a permanent staff of, say, four men and a

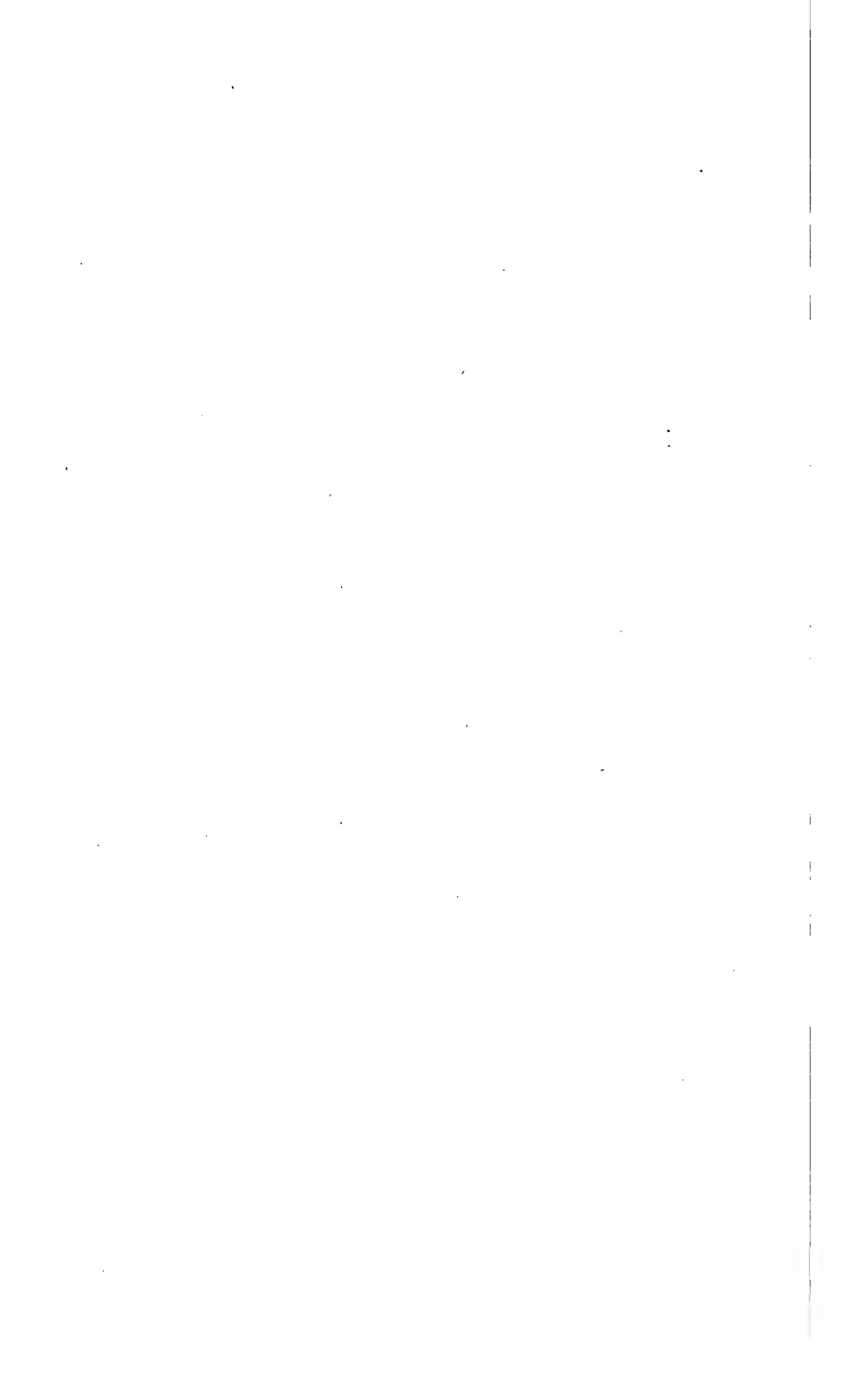
ganger. As the average quantity of metalling in the county at present is about 90 cube yards to the mile, the quantity required for each district would be about 1,800 cube yards; it might be possible to employ three men of the permanent staff breaking stone for three months each year, which would provide, say, 250 cube yards metalling, leaving 1,550 cube yards to be broken, or close on twelve months' work for four men, so that in reality the permanent staff would be, say, four stone-breakers and a cleansing and repairing gang of four men and a ganger, or nine men for each district—the cost being eight men at, say, 9s. a week, and a ganger at 12s. As there are about 600 miles of roads in contract in Longford, the annual cost of this labour would be about £6,550, or very nearly as much as the present cost of maintaining the roads; in addition there would be the cost of horses and carts for distributing the stone, which may fairly be put down at £300 for each district, or £900 for the county; and further, as an overseer would be required for every 60 or 80 miles of road we have, taking 80 miles as in his charge, and giving him £5 a week, and 10s. for car hire, a further charge of £546 for the whole county, bringing up the amount to £7,996 as against £6,600, the present average cost, being a difference in favour of present system of £1,400. Of course the work might not require so large a staff, but it would not be safe to commence with less, though it might be found practicable to reduce afterwards. Taking these figures as approximately correct they afford, in themselves, a strong argument in favour of maintaining present methods, and, when viewed in connection with the practical difficulties attendant on exercising a proper supervision over small bodies of men, scattered over a very wide tract of country, appear conclusive in favour of that system.

The third proposal—namely, labour paid directly by the authorities for the cleaning, repairing, and trimming the roads, and contracts for the supply of metalling—appears to

TOTAL	4,088,197	1,400,044	3,468,201	1	1,068,998	3,768,018	212,900	24,777	102,714	897,401	10,410	12 19	0	664	1
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combine all the objectionable features of the two previous proposals, without any corresponding advantages, as all the difficulty of scattered labour would have to be encountered, and also the necessity of closely looking after the supply of metalling, to prevent fraud and neglect, to see that the quantity is sufficient and the stones broken small enough. In fact, the surveyors and their deputies would have to look after two distinct bodies of men, both much scattered, and both equally inclined to shirk work, and to defraud, if possible. Again, as regards the question of expense, nothing would be gained, for, as before, we would require the permanent staff of four men and a ganger for every 20 miles, involving an expense for Longford County of about £3,750 and £546 for overseers, or a cost, without metalling, of £4,296. Putting down the metalling at 1s. 2d. per cube yard (a very low figure), we should require, allowing as before 100 cube yards to the mile, a further sum of £3,500, or a total for the county of £7,796, or £1,200 in favour of contract system.

The author, in conclusion, wishes to express his acknowledgments to the different County Surveyors who replied to his circular, giving such full information as to materially assist him in the compilation of this paper and the statistical tables attached to it; and to hope that some definite expression of opinion on this important subject, from the members of this Institution, may be the result of its discussion.

The author has prepared statistical tables showing the area, valuation, population, amount of county cess, and mileage of roads in the various counties in Ireland, giving the cost per mile of road for repairs. This table has been compiled from information obtained from the different County Surveyors, from the abstract books of the various counties, from the Local Government Board returns, and from other Government statistics. Care has been taken to make it as reliable as possible, and complete up to close of 1885.



The importance of the subject is the author's excuse for writing this paper. Grand juries expend on roads over £650,000 annually; town commissioners, on same purposes, over £12,000; and corporations, over £150,000. We have a total expenditure in Ireland, on road and street repair, of over £810,000 per annum, being something less than one-fourth of the local taxation of the country.

The foregoing pages refer solely to county roads. It would be interesting to have a paper on the maintenance and cost of roads and streets in the corporate towns in Ireland; and the author, in conclusion, would venture to recommend the subject to some member of the Institution conversant with street repairs.

Mr. WHITE said—Mr. Moynan commences his paper by stating what he believes to be the order of importance of maintenance labour on roads. He lays special stress on the necessity of drainage. Of course, this must in all cases be attended to more or less. He (Mr. White) quite agreed with him as to its special importance where the subsoil is of heavy clay, but where, as is often the case, it is of hard gravel or sandy in nature, the surface drainage is generally easily effected. Circumstances vary considerably, and each case requires special treatment. He is perfectly right as to the injurious effect of mud. When allowed to accumulate it very appreciably increases the quantity of materials required for maintenance; the worn particles, under pressure of horses' feet and wheels, retaining the moisture, soften and disintegrate the upper crust, unless kept constantly removed. It is on record with regard to Manchester streets after the scraping machine was introduced, that by cleansing the Macadamised streets three times a week the quantity of mud produced on the surface was only one-fifth of what was produced when swept by hand once in three weeks, and only one-thirteenth of what was produced when swept once a week.

Mr. Moynan makes very suggestive remarks as to the different methods adopted for the measurement and application of stones throughout the country. He agreed with every single observation the author has made on the subject. When he went to Longford first all the roads were done by measurement, and, finding it intolerably inconvenient, after some years he adopted the system of mere maintenance for the lighter roads, and it worked much better—it saved much trouble, as the contracts there were so small and numerous. The case is different in a county where the contracts are reasonably long, as in the Queen's Co., and where, in the event of deficiency, the contractor's payment can be "cut" at the end of each year in proportion to the value of the work remaining undone.

Mr. Moynan's ideas are quite right with regard to Baron Dowse's judgment. Possibly he might improve the wording of the specification, but as to the principle it is absolutely necessary often to require more materials than the minimum quantity specified. His general remarks on this point prove another disadvantage of the contract system. He might add that on roads in this county he had been enabled this year to carry forward a considerable proportion towards next year's supply in a large district.

In the Queen's County, as there is a more adequate staff of assistants in proportion, who do the measurement, the unsightly heaps he speaks of can be dispensed with. Neat square levelled floors are cut through at regular intervals into the water tables, of uniform size, on which the stones are laid in uniform rectangular blocks. As to the proper size of stones, he considered none should be over two inches, and for light roads should not exceed one and a half inches greatest diameter. Gravel screened for light material is much used; and the overseers for roads in his charge, being supplied with proper screens, see that this is done properly, and in many places the contractors do the same.

With regard to Mr. Moynan's observations on the present contract system, he says it is almost compulsory, if the security offered be considered good, to accept the lowest tender. He (Mr. White) would go further than this, and say it is absolutely compulsory. A case of the kind was decided some time ago on appeal in the superior courts. The author's remarks on the hardship of contractors having to wait in many cases for at least eight months for their money are undoubtedly true; but here the advance section being universally in operation, no hardship ever occurs.

He would now refer to the second part of Mr. Moynan's paper, in which he deals with suggested alterations of the present practice, and the probable future alternatives are so clearly classified that it becomes easy to discuss them in regular order.

The first suggestion is to continue the contract system as at present, but have it reformed so as to render it more efficient; and with regard to this he agreed with the author on two points he has put forward for improvement:—1st. That payments should be made oftener (but not of necessity) than at intervals of four and eight months; but this can be done readily at present by means of the advance section, which grand juries have power by special order to put in force. The law as it stands is satisfactory in this respect, but it would become necessary for all standard roads to consolidate the short contract lengths together, so that the annual payments should exceed the £20 required by the section. 2nd. Mr. Moynan has suggested that deductions be empowered to be made from contractors' pay in proportion to neglect. He quite agreed with him in this, and the idea has been discussed already. He did not, however, believe that proceedings at petty sessions could ever be made to work well, and all legal proceedings, in his experience, have been thoroughly unsatisfactory, with the exception of the ten days' notice, which he highly approved of;

but then in most counties there is no machinery to put it in operation when the notice has not been complied with, as is the case here; and, moreover, funds in most counties are not available either. These two difficulties being overcome, this remedy would meet most ordinary cases; and here he would direct Mr. Moynan's attention to the necessity of having a trained staff in the neighbourhood ready to do the work in such cases of neglect. This matter was further gone into at a previous discussion, and would imply—at least for success—that a due proportion of the county roads should be directly under the County Surveyors.

In his opinion, then, if the contract system is to be continued and reformed, the defects of practice found in some counties must be remedied, possibly compulsorily; for what is right in one county is considered wrong in another, where officials' interests are concerned. And next, a due proportion of the main roads must be permanently given over to the County Surveyors; and in connection with this we now come to the very difficult question of relative cost under the proposed modification, say, of giving one-third of the roads in each county permanently over to the County Surveyors, and two-thirds to the contractors. When he said very difficult he only referred to the difficulty in determining exactly the relative cost after the combined systems had been for some time in simultaneous operation. It is easy to determine what the relative cost could never exceed from known data—what may be termed the maximum—under these circumstances.

The certain data he had, were:—1st. That last summer assizes, by query book, he had 357·6 miles in his own hands at a gross annual cost of £13 8s. per mile, and that these included nearly all main roads, which gave universal satisfaction. 2nd. That there were 711 miles in contractors' hands at same time, at an annual cost of £12 6s. per mile.

Mr. Moynan states in his county there are 600 miles under contract at a cost of £6,600, or £11 5s. per mile nearly.

According to our present ratio, then, if 200 miles were in his own hands he would have 200 miles at £12 6s., and 400 miles at £11 5s. per mile—total, £7,120, a difference in favour of the old system of £520 per annum, which is the worst that could happen; and he felt perfectly certain that in practice, after the first year or two, the balance would be £500 at least the other side, and far better value would be given to the public in the way of good roads.

Second—Mr. Moynan puts forward the idea of doing away with the contract system altogether, and substituting that of paid labour. Now, with regard to this, considering that roughly half the work consists in supplying materials, and that ordinarily contractors can supply and deliver stones cheaper than could be done by day's work, there seemed no reason why materials should not be procured by contract, to which kind of work, from its very nature, none of the objections can be made that apply to maintenance labour. As a rule, he got all materials supplied by contract for this reason.

Third—Mr. Moynan puts forward and criticises the half-contract system applied universally in each county.

Now to meet his objections, Mr. White would refer him to the discussion at a late meeting of the Institution; also to observations in reply to Mr. Willson's paper. There is little more to be said, except that he believed it would practically be economical and efficient, but that most probably its partial adoption in each county, applied to scheduled roads (by compulsion), would best meet the views of all interested in the reform of the present grand jury system as applied to public works. A state of things corresponding to this has, through the force of circumstances and the hard logic of facts, been gradually brought about to exist in the Queen's County, and with

the very best results. It is not, however, in accordance with the spirit of the Acts of Parliament regulating these things, apparently, that such exceptional regulations should exist.

Mr. J. H. MOORE said—Mr. Moynan arranges road repairs under three heads: draining, metalling, and cleaning. He would be disposed to place cleaning second, making the order draining, cleaning, metalling, as a road must be cleaned before it can be metalled, and if a road can be kept dry and clean the wear is very small. And in this connection keeping the hedges cut—especially on the sunny side of the road—and overhanging boughs lopped, is of the utmost importance. Under the present Grand Jury Act this is no easy matter, as notices can only be served in winter, when the evil is less apparent, and if the occupier can succeed in delaying till the season is past he escapes till another winter. This has been altered in England, so as to allow notices to be served at any time, and the change should be extended to Ireland. It is also sometimes difficult to get orders to cut hedges to a reasonable height.

It is hardly correct to say there is no excuse for a badly-drained road. In level counties it is often difficult to get an outfall save at great expense, and by works outside the jurisdiction of the grand jury; and he knew many roads which run for long distances, half a mile and more together, below the level of the adjoining fields, and which could only be drained by covered sewers, which cost more than the cesspayers are generally disposed to grant. In stone drains he put 2-inch tile pipes at the bottom as preferable to French drains, and filled them to the top with field stones, as otherwise they are of no use to carry off surface water.

The difficulty of maintaining a road depends greatly on the

foundation. In Meath the great majority of the roads, even those constructed by the Board of Works in the famine time, have no foundation at all, and the crust of metal is generally only a few inches thick. This does very well when the sub-soil is sand or gravel or otherwise well drained, and the traffic not too heavy, but gives great trouble on clayey soils after continuous wet or frost. The very old roads are paved with large round stones, which are nearly as troublesome, as the metal is ground between the wheel and the flat stone, so as to wear out very quickly.

The system in Meath is exclusively maintenance contracts without measurement. The contracts run for 6 years, which checks the tendency on the part of the contractors to let the road wear out. While admitting that measurement gives better results on main roads, he did not think it is worth the increased cost. It involves additional assistants, great trouble and account-keeping, and gives opportunity for much dishonesty on the part of the contractor.

Mr. Moore considered the contract system to be the only possible one for road contracts, but undoubtedly several reforms were needed, especially as regards acceptance of the lowest tender, proceedings at Petty Sessions against defaulting contractors—which should be summary, with power to inflict a fine—and payments at equal intervals of six months.

There is an error in the table of statistics as regards Meath. The expenditure on roads and works in 1885 was £14,713 and £996 respectively, instead of £16,580 and £282 as given in the table.

Mr. MOYNAN, in reply, said:—Mr. Moore appears to have slightly misunderstood the order of road repairs given in the paper, which refers to their importance in effect, and not to the rotation in which they should be executed; undoubtedly,

cleansing is prior in time to metalling, but at the same time it is inferior in importance.

With reference to the proper drainage of roads Mr. Moynan did not state they could universally be easily kept drained, but from his experience he believed that by far the greater number of miles of roads in Ireland could easily and economically be drained much better than at present, and that the comparatively small expenditure thus incurred would more than be repaid in a couple of years. As regards the error in the tables referred to by Mr. Moore, the mistake occurred through putting down the year for which the table is calculated at 1885 instead of 1884, the last year for which the Local Government Board reports have been issued.

Mr. White is in error when he states that it is absolutely compulsory to accept the lowest tender for road repairs, as no authoritative pronouncement has yet been made on the subject, and different assize judges give different judgments. Thus, at Kilkenny Summer Assizes, 1885, the Chief Baron ruled in favour of the lowest tender, while either at the same assizes, or Spring, 1886, the going judge of assize at Carrick-on-Shannon ruled that the matter was completely in the discretion of the magistrates and cesspayers at Presentment Sessions.

With regard to Mr. White's further remarks on the advisability of labour gangs in counties instead of contractors, he (Mr. Moynan) had heard nothing that had in any way altered his opinion that from a financial view the scheme would be intolerable, and that as a working scheme it would be quite impracticable. He might mention that he addressed a circular, asking their views on the subject, to all the county surveyors in Ireland (forty-two in number), and received replies from only two in favour of such an alteration of existing practice, and from thirty-five against, five did not reply, so that the opinion of those most competent to judge



of the matter appears to be practically unanimous against Mr. White's proposals.

In conclusion, he had to again apologise for bringing so threadworn a subject before the Institution, and to plead the urgency of the matter at the present juncture as his excuse for doing so.

[7th April, 1886.]

**J. A. F. ASPINALL**, President,  
in the Chair.

The following Candidates were balloted for and duly elected, viz. :—

**PATRICK F. COMBER**, as Member; **JOHN M. S. GREEN**, as Associate.

The discussion upon the papers—"County Works in Ireland," by **F. R. T. WILLSON**, and "The Maintenance and Repairs of County Roads in Ireland," by **J. O. MOYNAN**—was resumed and concluded.

**A DESCRIPTION OF WOOD AND ASPHALT AS USED FOR THE PAVEMENT OF STREETS IN CITIES AND TOWNS.** By **PARKE NEVILLE**, Past President.

[Plate V.]

THE question of using wood for paving streets in cities and towns in place of square set stone pavement, asphalt of different qualities, and Macadam, has now for several years been discussed by city and town engineers, and in the metropolis of London large areas have been laid down of wood pavement according to different patents and plans.

Having recently need to make some inquiries into this important question, the author thought it would be useful to bring it under the consideration of the Institution, hoping that the facts he has obtained will afford members having such work to do, reliable data to act on. No theories are entered into, but he simply states what has been done in different cities and towns.

In the first instance, most of the systems and plans for wood pavements, also of asphalts, are described, for the details

of which the author is largely indebted for information obtained from a report made by Mr. Thomas C. Thorburn, C.E., Engineer to the Corporation of Birkenhead.

#### LIGNO MINERAL WOOD PAVEMENT.

The blocks used by this Company are cut obliquely in the form of a parallelogram, and therefore not likely to work loose, the surface of the timber used being grooved.

The timber, after being cut from the balk into blocks, is then sawn at an angle of about 60 degrees across the grain of the wood, so as to expose the fibre obliquely to the wearing face. By this means the strength of the fibre is utilised, and the resistance of the timber is considerably increased, while by the shapes thus acquired, when laid transversely, the weight from any one block is distributed to those adjacent to it, in the line of thrust ; rectangular blocks can be also employed, according to the nature of the traffic.

Near to the base of the blocks grooves are cut longitudinally, these are filled with asphalt mastic (pitch and tar), which is poured into the joints during the process of laying, and thus a powerful tie is effected throughout the system. After cutting, the sap is expelled from the wood by desiccation, and by subsequent treatment with hydro-carburetted oils the wood is rendered impervious to water, and proof against the certain decay which has hitherto arisen in wood pavements.

The blocks are laid on a concrete foundation in courses transversely to the street ; into the joints, when so laid, the liquid asphalt mastic is poured, this penetrates around the wooden blocks, and, being homogeneous with the mineralising agents, instantly unites the mass into one solid piece, perfectly waterproof, and capable of the utmost resistance. This pavement has been adopted in many streets in Paris, London, Cork, Hull, and other towns ; but, while possessing great endurance, it has been found too slippery to be recommended.

## THE IMPROVED WOOD PAVEMENT.

This description of wood-paving was in great favour in London, and has the great advantage that it can be taken up easily for the repairs of gas and water-pipes, or for sewerage purposes, and quickly relaid again without damaging the road, and without much hindrance to traffic.

It is now laid as follows :—The ground is beaten down, and a layer of cement concrete is made the basis of the pavements ; the surface trimmed to the proper transverse section or curvature of the road, so that it takes precisely the shape that the surface of the street is intended to assume.

Upon the concrete foundation, red deal blocks 6 in. deep, 7, 8, or 9 in. long by 3,  $3\frac{1}{2}$ , or 4 in. wide, are placed in rows running across the carriage-way.

Between each row of blocks a continuous strip of wood,  $1 \times 1$  in., is placed ; close against this strip another row of blocks of the same dimensions is laid—particular care being taken that the joints of the blocks in the first and second row should alternate with those of the first.

The spaces thus formed between the rows of blocks are filled in with gravel of suitable size, and run with liquid tar and solidly rammed, the whole surface being afterwards covered with small gravel, and made ready for traffic.

The cost of this kind of pavement complete in London is about 18s. per superficial yard.

The carriage-way of Bold-street, Liverpool, has been laid with this pavement, also a short length of Great Howard-street. In the original patent, deal planks being used as a foundation instead of concrete—the first idea of the Company being that planks formed an elastic foundation, and tended to distribute the weight equally over the whole pavement, while the additional elasticity saved the wearing of the blocks. This mode has since been abandoned by the Company, and the blocks are now, it is believed, in all cases laid upon a cement concrete foundation.

## HENSON'S STREET PAVEMENT.

This description of paving is formed and laid as follows :— The ground is excavated to a depth of 15 in. below the footway, and the surface generally levelled to the usual curvature of roadway ; the concrete bed is laid down, consisting of 6 in. of ordinary lime concrete, covered with 2 in. of Portland cement concrete. Upon this, when sufficiently set, is laid transversely and lengthwise, or transversely only, a covering of asphalt roofing-felt, the lengths of which are dressed on both sides with hot tar composition, and laid close together ; the blocks of the best Dantzic deal,  $9 \times 5 \times 3$  in., are then put down so as to break joint, with strips 5 in. wide of the same felt, also tarred between each course.

The grooved foothold blocks are inserted either throughout every fifth course, or at any intervals that may be found desirable.

At every fourth or fifth course of blocks a plank is placed against them, and the courses driven up with a sledge-hammer, so as to compress the interposed felt, and thoroughly compact any advancing section of the roadway.

No down fastening of any kind is required, and it only remains to dress the surface over with the tar composition and a little fine gravel.

A portion of Oxford-street, London, has been laid with this pavement, several years since. A short length of Church-street, Liverpool, was paved with this pavement about two years ago, and, it is stated, has given satisfaction. It costs in London about 14s. per yard superficial.

## THE ASPHALT WOOD PAVEMENT.

This system of pavement is formed by spreading a thin layer of mastic asphalt, about  $\frac{1}{2}$  inch in thickness, upon a concrete foundation ; wood blocks which have been previously prepared are placed thereon, in transverse courses, with the

grain of the wood upwards, and a space of  $\frac{1}{2}$  inch wide or more if desired being left between each course. The lower portion of the spaces, for a height of about 2 to  $2\frac{1}{2}$  inch up the block, is filled with heated asphalt which adheres firmly to the foundation, and is pressed into auger holes on each side of the block, thus solidifying the whole; the upper portion of the spaces is grouted with gravel and an asphaltic composition, affording a firm foothold.

The advantages claimed for this system are—

1st. "Safety, comfort, easy traction, noiselessness, durability, protection of pipes from frost, and less destruction from horses, shoes; also of carriage springs and tyres, the vibration being greatly reduced."

2nd. "The asphaltic wood pavement can be laid with rapidity, and repairs to sewers or gas pipes are effected with facility without in any way weakening or injuring the original foundation."

3rd. "Owing to its general solidity and strength of foundation, this pavement, it is stated, will be found to require less frequent renewals than other systems, thus securing a smaller amount of obstruction to the public traffic."

4th. "Hitherto a great objection brought against wood pavements has been the difficulty experienced in preventing the surface water from entering the joints, accelerating the decay both of the foundation and of the blocks. By the use of asphalt this difficulty has been thoroughly overcome, and the asphaltic wood pavement is completely impervious to water."

5th. "The asphaltic wood pavement requires no parting strips, which work to the surface and force out the interstitial filling, no useless contact of wood with wood *to retain moisture and promote decay*; hence its superiority in point of endurance."

"The cost of the asphalt wood pavement complete in London is about 16s. per superficial yard."

**CAREY'S WOOD PAVEMENT.**

This wood pavement is that which can, perhaps, be most rapidly laid down and repaired, and is formed as follows, viz.:—The blocks are cut 4 in. wide by 9 in. long, and to the depth of 5 or 6 in., according to traffic; these blocks are shaped with alternate concave and convex ends, and are laid on a bed of ballast or sand; the joints, which have been left about  $\frac{3}{8}$  inch wide, are filled with a grout of lime and sand.

The advantages claimed for this pavement are, that by the peculiar shaping of the blocks they will not be shifted from their positions, and, further, that the weight that may be put on each block is thus dispersed over an extended area.

The only special merit to be found in this system is that it dispenses with any preparation or foundation; it can be laid with great rapidity; but it is sufficient to say that the want of a good foundation must entail, to say the least of it, far greater inconvenience and much more waste of time than would be caused by making the under surface of the roadway firm and lasting.

To lay wood blocks on a hap-hazard foundation is to insure their irregular subsidence, the consequent unevenness of roadway, and a never-ending patching and piecing, becoming far wetter and annoying than the laying of a foundation would prove.

**MOWLEM'S WOOD PAVEMENT.**

Messrs. Mowlem and Co.'s method of laying wood paving is to form a foundation of concrete, varying in thickness according to the nature of the subsoil and the traffic; then to pave with blocks of yellow deal, 3 in. wide and 6 or 7 in. deep; the joints, which vary from  $\frac{3}{8}$  to  $\frac{1}{2}$  in., are filled in with sand and lias lime, and the surface is afterwards indurated by strewing it with shingle.

This wood pavement is, no doubt, an excellent roadway,

but it lacks one desideratum—namely, thorough imperviousness to water.

The surface water ought not to be allowed to reach the concrete bed, where it must sooner or later injure the foundations.

#### HARRISON'S WOOD PAVEMENT.

This system of wood paving (as yet untried) has some claims to notice. It consists of a concrete foundation, upon which strips of wood,  $2 \times \frac{1}{2}$  in. in thickness, are laid. Wood blocks, 3 in. in breadth, are placed upon those wooden strips, and heated asphalt poured into the joints, which penetrates under and adheres firmly to the blocks.

This pavement, like the asphaltic wood pavement, will undoubtedly be water-tight, but whether the elasticity expected to be obtained by placing the blocks upon strips of wood will be an advantage or otherwise remains to be proved.

#### CROSKIE'S WOOD PAVEMENT.

This description of wood pavement is formed by placing cross-grained planks of wood of any length side by side, and forcing them together by pressure, so as to form a compact homogeneous surface of wood, which has to be laid upon concrete.

#### ASPHALT PAVEMENTS.

Asphalt paving has been long in use with success for the surface of carriage-ways of the main thoroughfares in Paris.

The first asphalt pavement put down in England was laid in a part of the carriage-way of Threadneedle-street, London, in May, 1869, and was formed with the compressed asphalt of the Val de Travers Company.

The Moesler Asphalt Paving, the Trinidad Compressed Asphalt Paving, Patent British Asphalt Paving, Stone's Slipless Asphalt Paving, Foothold Metallic Asphalt Paving,



and Société Française des Asphalt, have been laid in small squares in London, also Barnett's Asphalt Paving and the United Limner and Vorwohle Rock Asphalt Paving has been laid in about 12 streets, and about 40 are paved with the compressed asphalt of the Val de Travers Company.

The mastic asphalts are the cheapest, their first cost being 15s. to 16s. per square yard (about 1s. 9d. for the concrete foundation, and 14s. 3d. for mastic asphalt), to be maintained free for two years, and afterwards for 15 years at the rate of 9d. per square yard.

The first cost of the compressed asphalts varies from 17s. to 18s. per square yard (about 1s. 9d. for concrete, and 16s. 3d. for the rock), to be maintained free for two years, and afterwards for 15 years at the rate of 1s. 3d. per square yard.

#### VAL DE TRAVERS ASPHALT PAVING.

Compressed asphalts are stated to have hitherto proved themselves the most durable, and the asphalt obtained from Neuchatel Asphalt Company's mines, in the Val de Travers, Switzerland, is by far the best. Mr. Thorburn describes the following particulars respecting asphalt rock, and the manner of laying the pavement:—

The rocks of the Val de Travers mine are composed of hard limestone, impregnated in a uniform manner with bitumen. The proportion of bitumen is 11 to 12 per cent., with about 88 per cent. of calcareous rock; whereas, in the Pyrmont Seyssel rock the proportion is only 6 to 8 per cent., and this is hardly a sufficient proportion of bitumen to enable its particles to consolidate quickly and thoroughly under the action of heat and compression.

The Auvergne rock is not at all like that of Val de Travers or Seyssel; it is much less homogeneous. The bitumen does not appear to have penetrated it in a uniform manner, and the proportion of bitumen absorbed is very variable. The pecu-

liarity of the Val de Travers rock is that it has neither too much nor too little bitumen, and that it admits of being easily disintegrated and re-integrated, so as to reassume its original homogeneous form without any admixture whatever.

In the formation of a roadway the rock is first ground, and then being subjected to a strong heat in a revolving boiler (which does not melt it), it is, when in the form of powder, spread on a bed of cement concrete, specially prepared, and being compressed with hot irons and rollers, it integrates or consolidates as it cools, and is re-converted into a homogeneous mass of rock, impervious to wet, and without any points or seams. The roadway is thus hermetically sealed, so that no moisture can penetrate either from above or below.

Of the mastic asphalts, without exception, that procured from the mines of the United Limner and Vorwohle Rock Asphalt Co., Limited, is stated to be the best, and the following particulars respecting it have been obtained.

The Limner asphalt is stated to contain from 17 to 20 per cent. of bitumen, and requires goudron (a kind of mineral tar) to be mixed with it in proportion of about 3lbs. goudron to every cwt. asphalt.

One ton of asphalt at a thickness of 2 inches will pave 12 square yards, or 24 square yards 1 inch thick.

Roadways for heavy traffic are generally laid with a thickness of 9 inches of concrete and 2 inches of asphalt.

Roadways for light traffic with a thickness of 6 inches of concrete and 1½ inches of asphalt.

The manner of laying down the asphalt is as follows:—A fire is first lighted under the boiler, then the goudron is put in. When this is melted 3 cakes of asphalt must be added, which have been previously broken in pieces about the size of a brick. Mix this together with a stirrer till the asphalt becomes soft, then put on the lid of the boiler and keep up a good fire

In a quarter of an hour add 3 other cakes of asphalt broken

as before. After this keep it well stirred, adding, as soon as one quantity of asphalt is melted, another quantity of 3 cakes and a goudron, till the boiler is sufficiently filled, say four-fifths full, thus leaving room for the grit, which is to be added when the mass is fairly fused in quantities of about 28 lbs. at a time.

As a general rule, it takes three and a half hours to prepare the asphalt. The boiling asphalt must be conveyed to the spreaders as quickly as possible in iron ladles or galvanised iron buckets. When two layers of asphalt are necessary, care should be taken to break the joints.

The great advantages of asphalt are, that it is less noisy than granite, or any other form of pavement, with the single exception of wood, and being smooth and without joints, the wheels of vehicles run almost as easily over it as they do on a street tramway, and what noise is caused by the traffic comes almost entirely from the clatter of the horses' feet upon the asphalt. Then these kinds of pavements can be easily repaired.

In compressed asphalts repairs can be so neatly effected as not to be noticeable after a short time, and when first laid or when repaired it is fit for traffic a few hours afterwards, it is left clean, and causes no inconvenience from dirt or dust. Asphalt being impervious to moisture, water runs off it quickly, or is soon evaporated.

The great objection to asphalt pavement is its great slipperiness in frosty weather, or in misty, sleety, or foggy weather; though, on the other hand, it could be kept cleaner than any other pavement, for being non-absorbent and without joints, the broom, scraper, shovel, or water could be applied to it most effectively. Another objection to asphalt is that in dry weather a fine dust arises from it, which is stated to be obnoxious to traders having fine goods, but dust is unavoidable whatever the pavement.

From a report of Colonel Haywood's, Engineer to the

Honourable Commission of Sewers in London, dated 17th of March, 1875, in whose hands all the works of paving, Macadamising, lighting, sewers, and street improvements are placed, that the first wood pavement laid down within the city of London was in 1839; it appears there was considerable diversity of opinion whether the wood or granite was preferable, all things considered, and a prejudice arose against wood, and as the pavement wore out they were replaced by granite.

Wood was, however, retained in Miner's-lane, Gracechurch-street, Lombard-street, St. Bartholomew's-lane, Old Bailey, until within the last three years, when, with the exception of St. Bartholomew's-lane, all was replaced with asphalt.

Colonel Haywood states that up to 31st December, 1873, the following lengths and areas of wood pavement existed in the city of London :—

		Length yards	Area super. yards
Carey's Patent	...	134	946
Improved Wood Company	...	701	9,545
Ligno Mineral	...	27	410
Mowlem's	...	171	1,053
Stones	...	26	284
Total	...	1,059	12,238

On the 31st December, 1873, the areas of streets asphalted were as follows :—

Pavement		Length yards	Area super. yards
Val de Travers (Compressed)		4,185	34,876
Do. (Mastic)	...	69	232
Limner Mastic	...	1,446	8,477
Barnett's Mastic	...	1,705	16,544
Société Française (Compressed)		39	327
Montraleer (Compressed)	...	40	346
Total	...	7,484	60,802

He says no two pavements, whether of wood or asphalt, are found to be exactly similar in their qualities.

Colonel Haywood selects for comparison the compressed asphalt of the Val de Travers Company, and the improved wood pavement as being (then) considered the best examples of their several kinds.

The Compressed asphalt pavement of the Val de Travers Company is laid upon a bed of compressed concrete in a state of heated powder, and so as to be, when compressed, from  $2\frac{1}{2}$  in. to 2 in. thick, according to the traffic of the street.

The improved wood pavement (planking now condemned) is formed of fir blocks,  $3\frac{1}{2} \times 9$  to  $10 \times 6$  in., laid on a foundation of two thicknesses of fir planks, well pitched and riveted together. The blocks are placed close together at their ends, but on their longer sides are joints running from side to side of the street, joints being kept by fillets nailed to planks ; the joints are filled up with clean, small pebbles, rammed in and then lime with composition of pitch tar or other bituminous substance.

The Colonel remarks :—

The sole object of adopting either wood or asphalt is to diminish noise.

Asphalt is less noisy than granite. Wood is less noisy than asphalt, and the least noisy of all pavements.

Asphalt cannot be suffered to get materially out of repair, for if it does it is speedily knocked to pieces.

Wood pavement being composed of blocks of different sizes, jointed in different modes, are in course of time worn into inequalities. When this occurs there is more jolting and noise, but this chiefly affects occupiers in the carriages.

Asphalt being impervious, water runs rapidly off it ; dirt lingers on wood.

It has been said wood pavements at times smell offen-

sively and may be unhealthy; but wood has been down in city for 30 years, and no complaints made to the Commissioners on this point.

In the northern towns in Europe timber paving is largely used. In America and Canada many of the largest cities are paved almost entirely with wood.

Asphalt and wood have therefore each in some degree advantages which the other does not possess—the former dry, clean, and pleasing to eye; the latter more quiet and pleasant to draw on.

Asphalt and wood should be kept very clean for safety, but cleanliness is more important to asphalt.

Washing best way of cleansing asphalt and wood.

Gravel should be put over wood pavement when complete for traffic to grind in; and continued to be laid on as required.

He observes—"It is easier to keep asphalt clean than wood."

Small repairs can be made with facilities in asphalts; in compressed asphalt the joints cannot be noticed, but there are seams left in mastic asphalt.

Repairs easier made in asphalt than wood, and require less area to be opened for repairs to pipes.

Some years ago in two streets, one paved with a hard sandstone much used, and the other with asphalt, showed that on the stone pavement one out of every 1,308 horses fell, and in that with asphalt, one in 1,409.

Some time back (he states that) a petition signed by 24 horse owners (including the General Omnibus Company, ten of the largest English carriers, the managers of three railway companies, and cab and omnibus proprietors—16 of the petitioners stated they owned amongst them 13,448 horses) stated in their opinion asphalt pavement was objectionable as compared with granite.

Colonel Haywood had experiments made in 1873 of a most

exhaustive character over granite, wood, and asphalt pavements, that showed wood was safer than asphalt, and the accidents on it of a less objectionable character. The experiments continued for 50 days of 12 hours daily, and the aggregate distance travelled by the horses was 478,523 miles. The aggregate distance travelled by the horses during the observations was, on the asphalt, 203,805, and on wood, 179,154 miles.

Slipperiness can be temporarily cured by sand on asphalt, and gravel on wood.

When a horse falls upon asphalt he has difficulty in getting up, and can do it easier on wood. The Colonel here gives the results of some of the experiments, which will be found in his valuable report, but would be too tedious to repeat here.

In times of frost there is little difference; the asphalt dry and safe, the wood retaining moisture is very slippery.

In part of city a short length of street paved with asphalt has a gradient of 1 in 46, another 1 in 57. The Commission in 1871 determined to lay no pavement with steeper gradient than 1 in 60.

The wood pavement in St. Bartholomew's-lane (Carey's improved), the gradients, 1 in 34; in King William-street, 1 in 30 to 1 in 37, in some spots 1 in 20; Ludgate-hill has a gradient of 1 in 26; and all are safe. Wood, therefore, can be laid with steeper gradient than asphalt. When a horse falls on asphalt he has a difficulty in getting up; on wood he rises more easily.

So far as the facility with which a horse can recover itself, it is in favour of wood; for quick speeds wood is superior.

As to durability, he stated—

Asphalt first laid in Paris in 1854.

The author thinks that without much repair none of the asphalts would last more than from 4 to 6 years, and that in

course of from 6 to 10 years the *entire* surface of all will have to be renewed.

Further valuable tables from Colonel Haywood's report are included in appendix.

Colonel Haywood's conclusions are:—

Pavements cost more or less according to the width and traffic of the street.

Wood, it appears from tables, will be dearer than compressed asphalt.

As regards convenience, asphalt is the smoothest, driest, cleanest, and most pleasing to the eye; but wood the quietest.

As regards cleansing, that the wood may be kept cleaner, but will be more expensive to cleanse effectually than asphalt.

As regards construction and repair, the asphalt and wood, taking all seasons and weather into account, can be laid and repaired with about equal facility. The most durable repairs can be made on asphalt.

As to safety, wood is superior to asphalt.

As regards durability and cost, wood pavements, with repairs, have a life varying from 6 to 19 years, and without repairs about 10 years.

As to asphalt, its durability is not known, but under the system of maintenance adopted may last as long as wood.

In January, 1882, Colonel Haywood made a further report to the Honourable the Commissioners of Sewers of the City of London, including a return giving the annual cost of maintaining various asphalt, wood, and granite pavements.

Asphalt pavements are, as a rule, maintained by the contractors subject to the following conditions:—

Contracts are for a term of 17 years; for first two years the pavements are maintained at the cost of the contractors, for the remaining 15 at the cost of the Commissioners at



prices per square yard per annum; at the termination of the contracts they are to be left in a good condition to the satisfaction of the Engineer, so that a square yard of asphalt is not to weigh less than a specified weight.

*Wood pavements*—The contracts are made on the same conditions as above; at the termination of contracts the pavements to be delivered up in good condition to the satisfaction of the Engineer.

On the 29th April, 1879, Mr. George Frederick Deacon, Engineer to the Corporation of Liverpool, M.Inst.C.E., read a paper before the Institution of Civil Engineers in London, on "Street Carriage Pavements," which gave the results of his experience, and after this paper was read, Mr. Osbert Henry Howarth, Assoc. M.Inst.C.E., read a paper, "Wood as a Paving Material under Heavy Traffic." The discussion on both papers was taken together immediately after they were read.

The facts stated in the papers and brought out on the discussion are of the most valuable character, deserving to be studied by road surveyors.

Mr. Deacon says that as to breadth of stone sets he recommends that it should not exceed  $3\frac{1}{2}$  inches; for length he uses from 5 to 7 inches.

#### *For Hard Stones.*

	Depth.	Width.	Length.
For moderate traffic, -	6 to $6\frac{1}{2}$	4 to 14	5 to 7
For heavy traffic, -	7 to $7\frac{1}{2}$	4 to 14	5 to 7

*Materials for Sets.*—Among the igneous plutonic and metamorphic rocks are to be found a great variety of stones suitable for paving.

The late James Newlands, Borough Engineer of Liverpool in 1851, introduced the following plan of forming a foundation under the new square set pavements then largely being

laid down in place of the old Macadam or boulder stone pavements.

He excavated the carriage-way of the street to a depth of about 18 inches, then got all the old Macadam or other material fit and laid down a Macadamized street, the upper surface of which was in or near the level to lay down the new set pavement, the traffic was allowed to run for months on this, and, when considered fit, the surface was levelled, all hollows made good with concrete, then an inch of pebble, and then on this the new sets were laid; the joints were then grouted and a capital durable carriage-way was formed.

Mr. Deacon now recommends a concrete foundation. The most perfect concrete the author has produced is made as follows :—

The ground on which the foundation is to be laid is first well watered; upon this is then scattered a layer of wet broken stones, upon this layer is spread a thin stratum of cement mortar, and upon this mortar a further layer of broken stones; the upper layer of broken stones is then beaten into the lower layer with beaters like large spades; another stratum of mortar, followed by a third of stones, until the required thickness is attained, when the surface is first beaten, and then finished by rubbing with beaters to the proper curvature of the carriage-way.

The cost of constructing a concrete foundation as above described is given at 3s. 9d. per square yard.

Foundations of bituminous concrete in Liverpool 6 inches deep cost 3s. 6d. per square yard.

#### WOOD PAVEMENT.

In 1872, Mr. Deacon recommended wood pavement to be tried in Great Howard-street, Liverpool, where the traffic exceeds 3,300,000 tons annually, or 216,000 tons per yard width of carriage-way. Half the work, about 700 square

yards, was accordingly paved by the Improved Wood Pavement Company.

The southern half was laid by different contractors on a material which, he states, was dignified by the name of concrete; the blocks were of Baltic pine, grouted with Portland cement, *a material quite unsuited to be used in combination with wood*; and after ten months' use the pavement became dangerous, and was entirely relaid on the sound system at the contractor's cost, but after twelve months had to be removed, showing, he states, the want of a good concrete foundation.

In 1874, Bold-street (the Grafton-street of Liverpool) was laid by the Improved Wood Pavement Company; the traffic, chiefly carriages, was equal to 94,000 tons per annum, per yard in width; but even here the want of concrete foundation soon became manifest—the whole pavement was worn to the extent of  $\frac{5}{8}$  of an inch in 4 years.

#### COST OF PAVEMENT PER YARD SUP.

	£	s.	d.
Improved Wood Pavement laid in Great Howard-street, including double plank foundation - - - -	0	16	0
Improved Wood Pavement laid in Bold-street, including double plank foundation - - - -	0	15	3
Henson's Wood Pavement as laid in Church-street, including bituminous concrete foundation $3\frac{1}{2}$ deep, -	0	15	10

Mr. O. H. Howarth, in his paper, says that a series of observations collected by him tend to show that, against all discrepancies which render comparison in street traffic doubtful, opposite conditions are found to arise by which they are compensated. It is often assumed, on the one hand, that a

generally slow speed, consequent on heavy loads, is less destructive than a light, rapid, and percussive traffic. In this respect, however, compensation is proved to exist in the actual crushing pressure, and increased weight, and effort of horses, as against the more frequent sudden pounding or tearing of other wear. Again, the central portion of a road is naturally considered to sustain the brunt of traffic as compared with that which passes to the sides; yet in 5 streets out of 10 observed, this is fully compensated by the fact that the sides of a roadway are subjected to the greater or less continuous wear of the vehicles driving up and pulling off again; and, secondly, by the fact that all streets where the traffic is numerically such as to control the necessity of an up and down line, a limited section of the centre of the street is more or less protected.

He argues also, and the author thinks rightly, that the value formerly placed on the curvature in cross section given to streets where large, heavy, and quick traffic passes is altogether over-rated, and maintains that the blow given the surface of the street by the traffic is not spread or expended on the arched surface, but is sent more or less right through the paving set, wood, stone, or asphalt; but this should not prevent the cross section having a proper camber to secure proper surface drainage.

This points out too the absolute necessity of a good firm unyielding foundation of concrete.

Mr. Deacon gives tables showing the number of vehicles which passed through certain streets in London in 16 hours, but it is unnecessary to introduce them into this paper.

Mr. Woulfe Brenan, having been engaged for a few years as manager of the Ligno Mineral Paving Company, desired to direct attention to the life of wood pavements. Wood had been in use for 7 years; almost every kind of wood had been tried—beech, elm, oak, pitch pine, and Baltic fir. The result of his experience *was that the wood must be treated*

*merely as a surface; the concrete foundation was the real basis of the pavement.* He was of opinion that wood pavements would not wear for more than four or five years at the outside. He, therefore, believed the shallower the blocks the better.

Mr. Stayton, Surveyor to the Chelsea Parish, made some excellent remarks based on his great experience.

Mr. Isaacs was of opinion Henson's plan was not the best; preferred the Asphalted Wood Pavement Company.

Mr. Deacon, in replying, said he agreed with the suggestion that the surface of a *roadway should be treated as a veneer to be laid on a permanent* foundation not subject to wear; 5 inches in depth would give a sufficient bite to blocks if the traffic did not much exceed 100,000 tons per yard. It would be a mistake to put down sets either of wood or stone of too great depth.

Cement grouting was not so desirable as bitumen, when the sets had to be removed for gas or water purposes.

#### SUNDERLAND—1881.

Armstrong, Addison, and Co., first laid down their preserved wood pavement in 1867, and after 14 years' experience can recommend it. It has been laid on Sunderland Bridge, where heavy traffic has been constantly passing over it, and is now perfectly sound and in working order, although not at any time repaired.

#### CREOSOTED BEECH PAVEMENTS.

Used—London, West	...	...	Metropolitan Tramway
Liverpool	...	...	Main Streets
Bristol	...	...	Tramways
Worcester	...	...	Do.
Darlington	...	...	Do.
Newcastle-on-Tyne	...	...	Do.
Carlisle	...	...	Do.
South Shields	...	...	Do.

Is cleanly, only one-third of a load of mud being taken on an average from 1,000 yards surface of wood, against two loads taken from granite and four from Macadam roadways.

Blocks laid on foundation of 5 to 6 in. of concrete; blocks 5 to 6 in. deep, 7 in. wide, 6 to 12 in. long, set on a thin layer of sand, joints run with asphalt and small gravel.

“Further experience has shown that creosoted beech on Sunderland Bridge has worn less in 14 years than some granite sets put down at the north end of the bridge 4 years afterwards.”

They say—To secure a lasting pavement it is necessary to select hard, tough wood, and to preserve it thoroughly by impregnating it with preserving liquid of suitable quality under steam pressure in strong iron cylinders. It is almost useless merely dipping the wood. Timber thus treated is not preserved.

Beech or other wood is creosoted under a pressure until they absorb a minimum quantity of one gallon, equal 10 lbs., per cubic foot. There is no difficulty experienced, we are informed, in impregnating beech with 12 to 15 lbs. per foot.

This firm are in favour of cutting red wood blocks from Memel, Dantzig, or Stettin timber or deals, in preference to Swedish, as they consider the former tougher and more durable.

George R. Strachan, C.E., Surveyor to the Chelsea Vestry, in a report to that Vestry, 27th Oct., 1885, gives the following statistics of some of the leading streets recommended for wood pavement.

Estimate includes new gutters, and raising old ones. Cost of maintaining wood pavements to get 7 years' life is only one-eighth of what it costs to maintain it as a Macadamised road. Cost of scavenging wood in a street like King's-road is only one-sixth of what it costs to scavenge a Macadamised road.

	Tons per 16 hours from 6 a. m. to 10 p. m.	Tons per yd. of width	Approximate Estimates
			£ s. d.
1. King's-road .. ..	5,091	515	4,187 0 0
2. Paul-street .. ..	3,861	265	3,742 0 0
3. Church-st., N. of King's-road	2,736	316	2,161 0 0
4. Oakly-street .. ..	2,291	168	2,382 0 0
5. Devonport-st., N. of King's- road .. ..	1,936	92	2,096 0 0
6. Robert-street .. ..	1,935	159	2,251 0 0
7. Church-st., S. of King's-road	1,639	251	1,210 0 6
8. Sidney-street .. ..	1,053	82	1,460 0 0
9. Beaufort-st., S. of King's-road	915	92	1,727 0 0

Mr. A. Brown, in a paper called "Five Years' Municipal Work in Nottingham," dated 16th May, 1885, states, paving usually adopted for most of the streets are granite sets  $3 \times 5$ , or  $3 \times 6$ , on a foundation of concrete 8 inches thick; the joints of the paving are run in with a composition of pitch and tar.

There are about 15,000 square yards of wood pavement in the town, of which 13,000 square yards have been laid during the first five years, both creosoted and uncreosoted red deal; also creosoted beech blocks have been tried. The cost of wood paving with ordinary creosoted red wood blocks, and including 8 inches of concrete, is 11s. 7d. per yard; this price includes taking up old stone, excavating and preparing ground, and carting away old materials and stones, and everything complete—the cost of wood being from 6s. to 6s. 4d. per yard superficial, including laths. The cost of the wood only for the beech block is about 9s. per yard; creosoted beech paving blocks cost from 2s. 8d. to 3s. per yard superficial more than creosoted red deal paving.

The *sine quâ non* for wood paving is a thoroughly good concrete foundation.

Mr. Brown says that he has heard that in some towns wood paving has been extensively laid on the natural ground without any concrete foundation. *He would expect to hear that this paving would be in a ruinous condition after a few years' wear, unless the traffic is nil.*

The above remarks of Mr. Brown bears very much on a case recently inquired into by the author—viz., the system of wood pavement introduced into the City of Norwich.

He visited this city the latter end of October, 1885. The area within the municipal boundary is 4,772 acres, and the valuation of the city is £267,750, and the population 87,842. The total length of the streets is about 70 miles, of which there are now about  $6\frac{1}{2}$  miles paved with wood; these were formerly paved with either flint pebbles, or were Macadamized. Wood pavement was first introduced or tried some 7 or 8 years ago, when it was laid down on concrete, grouted, &c., on the same system generally used in London, and in the large cities and towns in England, Scotland, and also in Dublin, and this cost from 12s. to 13s. per superficial yard.

This was considered too expensive, and the idea suggested itself to the City Engineer of Norwich to dispense with the concrete foundation.

In 1881 the Corporation of Norwich obtained a loan of £25,000 for wood pavement, and in the years 1881 and 1882 the sum of £24,036 17s. 10d. was expended on 19 streets, having a collective area of 75,638 yards superficial. The estimated cost was 7s. per yard; the actual cost was from 5s. 6d. to 8s. 2d., as per Report of Carriage Pavement Committee to Town Council of 17th January, 1883.

A subsequent loan was obtained of £5,000 for wood pavement; the estimated cost was 7s. per square yard, and the actual cost is given by the Committee at 4s. 5d. per yard for



streets where little of the surface was required to be disturbed, to 4s. 10½d. per yard on others.

The timber used is stated in the report to be various species of red Baltic wood of different sizes.

The Executive Sanitary Officer of Dublin visited Norwich in October last, and made a report greatly in favour of the system adopted in Norwich, and recommended it to be used in Dublin.

The system of wood pavements in Norwich was in opposition to all the author's past experience, and raised a very serious question, as to whether wood pavement as done in Norwich, and at such prices, would be found to answer?

It is desirable to place before you the following views, as there can be no doubt that the wood pavement laid down there, from the year 1881 to latter end of 1885, has only cost from 4s. 5d. to 8s. 2d. per superficial yard; and the author invites consideration to the circumstances, and the probability of it turning out durable.

The durability of all pavements depends on the traffic over it, to which, in the case of wood, the liability to rot has to be added.

If a roadway be laid down formed with stone paving sets, asphalt, wood, or Macadam, and over which there is little or no traffic, all will last in repair indefinitely, except that in course of time the wood will rot.

Again, the material to be used for the carriage-ways of a city or town must depend on the cost.

In the case of Norwich, the traffic is of the lightest, both as to the number of vehicles and weight, and is quite exceptional. The author walked over many of the wood-paved streets with the engineer's assistant, and he observed this, and remarked on it; this gentleman admitted it, but the day was very wet, and he said the traffic would be heavier and greater the next day, Saturday, which would be market day. He visited several

streets on that market day. and saw very few vehicles, although there was a large market being held (the cattle market being in the centre of the city). It may be estimated that the vehicular traffic which passes daily over a large proportion of our private streets is as great as that passing through the central streets in Norwich.

With regard to material, there is no good road material either for paving or Macadamizing to be got at a practicable price. In the streets paved with pebble the stones are round or oval-shaped, about 4 inches in diameter, and all of a flinty character.

The plan adopted, the author was informed, is as follows:—When a street is about to be paved with wood, the round stones are removed, the surface on which they rested is levelled, and 1 inch or so of sand is laid on this, and then the wood blocks bedded or laid on the sand. Where the streets happened to be Macadamized, this was removed ; if a portion was deeper than required, 1 inch of sand was laid down, and then the wood sets bedded on this. If the Macadam was not deep enough, and levels of surface required to be raised or lowered, this was done with the clay or rubbish at hand, and then 1 inch or so of sand was spread over it, and on this the wood blocks were laid. On the Princess-road the surface level was in parts altered 18 inches, and yet over this the same system was adopted of spreading 1 inch or so of sand, and on this the blocks were laid. In all cases, it was stated, great care was taken in ramming the blocks.

As to adopting a plan of laying down wood paving blocks, on ground newly excavated for a road, and on a bottom of clay, and with only 1 or 2 inches of sand or gravel laid over it, such a plan would, in my opinion, never stand under ordinary, not to mention very heavy traffic, and the whole question resolves itself into this—that what may by possibility be found to do in Norwich under the exceptional circumstances

described would totally fail in streets in London, Birmingham, and Dublin, or cities having heavy or even moderate traffic.

These pavements, even under the light traffic, have only been laid down from one to three or four years—far too short a time for a reliable test, and the author's eye could see uneven settlements showing in many cases, the Princess-road included. In fact, the system is a bad imitation of Carey's plan.

The author visited Sir Robert Rawlinson in London after this visit to Norwich. He is altogether in favour of wood pavement, but he adds it is on the understanding that there must be a thoroughly good foundation of concrete provided to lay it on, as he regards the stone, wood, or asphalt only like a veneer on the concrete foundation which is the real road.

It is considered absolutely unnecessary to go fully into the details of this system of Norwich wood paving, because the author feels that the recommendation to adopt it largely in Dublin was calculated to lead to waste of money.

In conclusion, he begs to summarise his own views on street pavement:—

1st. Where there is very heavy traffic, or very much light vehicular traffic, travelling quickly, he believes the best and most economical materials are paving sets, obtained from the igneous, plutonic, and metamorphic rocks and quarries, or the syenite granites (pure granites like the Dalkey, Ballynockin, or Newry are unfit). They should be thoroughly well dressed, so as to enable close jointing. The sets should be laid on a bed of thoroughly well made Portland cement concrete, mixed in the proportion of at least 6 parts gravel and sand to 1 of cement, and when laid down the top surface should be carefully faced over with Portland cement mortar, and then be allowed to set and not paved on for at least ten days, and if heavy rain or frost occur during this time of setting the cement should be protected by tarpaulins. The sets should, at the end of

the ten days, be carefully carried by barrows working on planks, to the site to be paved. The sets he prefers to lay skin to skin, or certainly with a joint of not more than  $\frac{5}{8}$  in. thick, and after being carefully rammed, the joints filled with fine pebbles, and run with a mixture of pitch and oil.

Taking the price of the paving sets at 24s. per ton, and Portland cement at 40s. per ton, the estimated cost of getting the work done, without contract, is 12s. 6d. per superficial yard, including excavation and carting.

With regard to the price at which wood pavement could be laid, it will vary with the quality of the timber used, as also whether there is a concrete foundation or not.

It is estimated that the best class of wood pavement can be laid, using beech blocks costing £5 12s. 6d. per 1,000 blocks, with a foundation of 6 in. of good Portland cement concrete, for about 9s. 8d. per yard, and if the blocks are creosoted, 11s. 6d. per yard; this would be the best and most durable class of wood pavement that can be laid, and suitable for very heavy traffic.

Wood pavement, using red deal and a concrete foundation, will cost 8s. 8d.; without concrete, 7s.; American spruce pine with concrete foundation, 7s. 7d.; without foundation, 6s.

The Val de Travers or Limner asphalts make admirable carriage-ways, and are very durable, and the work is contracted for, as in the city of London, for a given price per superficial yard, and when laid to be kept in repair for two years free of charge. Further, on the expiration of this, for 15 years for a fixed sum of from 9d. to 1s. 6d. per yard, and at the end of contract to be given up in perfect order and repair. The author thinks it would prove the cheapest and most easily kept clean roadway known. Its only drawback is slipperiness; but the danger from this can be much minimised by proper scavenging and sanding.

After all that the author has mentioned and quoted, he need hardly say that he totally disapproves of using stone or wood without a concrete foundation. In some cases, if a good coat of strong Macadam can be left under the wood blocks, and all inequalities of surface under the blocks be made good with concrete, the 6 in. of concrete might be dispensed with, provided the traffic is light, but not otherwise.

As to openings obliged to be made for gas, water, or sewer purposes in paved streets, wood or stone, the greatest care should be taken in their repair—a class of work which is generally much neglected. The earth should be first carefully rammed in layers as being filled in, then the sets should be temporarily, but carefully, laid in with a little ramming; then, after a fortnight or so, the sets should be taken up and the earth excavated to the necessary depth for getting in from 6 to 8 inches of concrete, which, after being allowed a short time to set, the paving sets should be carefully laid down and properly rammed. The want of this precaution is the cause of just complaints.

Annexed are appended replies received from the surveyors of 11 of the vestries in the metropolitan district of London, and 38 from the surveyors and engineers of several of the large cities and towns in England and Scotland. In a few no wood pavement as yet has been laid unless to a trivial extent, but in all where wood pavement has been to any extent laid down it will be observed that in every case a concrete bottom has been used.

**SCHEDULE showing the result of inquiries made in London and several of the large Cities and Towns in England and Scotland respecting the experience of their Engineers and Surveyors of the use and mode of Construction of Wood Pavements, and especially as to the use of Concrete Foundations.**

	Name of City, Town, Vestry or Parish	Area in yards super-ficial	What plan of Pavement is adopted? If by Contract? Quality of Timber? Description of Foundation? Breadth of Joints? How Grouted? Are Laths used? Size of Blocks? If Beech is used?	If new Pavement has been ever laid without concrete bottom, or on old bottom under macadam	Cost per yard superficial	Life and Wear of Blocks	Opinion of Medical Men as to Wholesomeness	Cost of Maintenance	Cost of Scavenging per yard superficial	Cost of Scavenging Wood as compared with the best Set Paving
1	LONDON: — St. James	60,000	Principally plain pitch pine; but yellow deal only is now used. Foundation Portland cement concrete, 6 to 1, 6 in. deep. Laths are used, but removed before grouting. Cement grout, $\frac{1}{2}$ in. joint. Blocks $9 \times 6 \times 3$ .	No.	Last contract, $\frac{7}{8}$ . $9 \times 6 \times 3$ best yellow deal, £5 14s. per 1,000.	5 years in busy streets, 9 to 10 in side streets, but many repairs wanted.	—	Varies very much.	Cost much more than asphalt.	—
2	Whitechapel	3,070 to 4,000	Henson & Co.'s Improved Paving. Deal and beech by tram rails. Portland cement concrete, 3 in. to 6 in. thick. Laths. $\frac{1}{2}$ in. joint, part tar and pitch, and then filled in with cement grout. Block $8 \times 6$ .	No.	8/- per yard.	About 7 years.	—	1/3 per yard.	—	—
3	St. Marylebone	90,000	Improved Henson's Asphaltic, and others. Yellow deal blocks, principally $9 \times 6 \times 9$ , sometimes $3 \times 5 \times 9$ . No elm or beech used. Portland cement concrete, 6 in. deep — 1 of Henson's to 4 or 5 of Thames ballast. Henson's jointed with felt, grouted with tar. Other systems not now used. Present system has perfectly close joints, grouted with boiling tar and pitch. It is perfection.	No.	The new system where 8 in. cement used over old, about $\frac{7}{8}$ per yard. Blocks, £5/12/6 per 1,000.	Henson's lasted 9 years in Oxford-street, other systems as long in light traffic, some worn to $1\frac{1}{2}$ in. Henson's only to 3 in. or $3\frac{1}{2}$ in. after 9 years.	—	Difficult to estimate.	—	—

*SCHEDULE — continued.*

	Name of City, Town, Vestry, or Parish	Area in yards superficial	What plan of Pavement is adopted? If by Contract? Quality of Timber? Description of Foundation? Breadth of Joints? How Grouted? Are Laths used? Size of Blocks? If Beech is used?	If new Pavement has been ever laid without concrete bottom, or on old bottom under macadam	Cost per yard superficial	Life and Wear of Blocks	Opinion of Medical Men as to Wholesomeness	Cost of Maintenance	Cost of Scavenging per yard superficial	Cost of Scavenging Wood as compared with the best Set Paving
4	LONDON—cont. Strand	—	A system similar to that used by the Engineer of the Metropolitan Board of Works. Cressedot Baltic blocks. Portland cement concrete foundation, 9 in. to 12 in. Blocks laid on floated surface of concrete, and the joints grouted with hot bituminous mastic and Portland cement. Laths removed before grouting. ½ in. joints. Blocks 9×3×6. No beech or elm used.	—	10/7 including excavation.	7 years.	—	1/-	—	—
5	Holborn	16,387	The Improved Wood Paving Co.'s system, and that of the Asphaltic Wood Paving Co. Best Baltic yellow deal, cressedot. Portland cement concrete, 6 in. deep, mixed in the usual proportions. Joints ¼ in. wide, grouted half in asphalt and half in cement. Laths are used. Blocks 9×6×3. Never used elm or beech.	New bed of concrete invariably laid down.	12/6 on an average. Blocks delivered at £2 per 1,000.	Under greatest traffic, say Holborn, 5 years, medium traffic 7 years. Some blocks worn down 2 in. after 5 years wear.	Medical men in London are agreed that wood pavement is objectionable owing to the effluvia given off therefrom.	1/-	No data.	No data.
6	St. Mary, Newington, Surrey	—	The Liverpool Wood Paving Co. Deal blocks, Portland cement concrete, 6 to 1, 9 in. to 6 in. in depth. Blocks 9×6×3. No beech or elm.	Always on new concrete foundation.	10/- to 12/8.	4 to 7 years; from 1 in. to 3 in. from 4,000 to 6,000 carriage traffic per day of 12 hours.	No.	1/- to 1/9	About half that of macadam.	One-fourth that of macadam.
7	St. George, Hanover-square	120,000	Various; chiefly the Improved Wood Paving Co. Best deal. Portland cement concrete, 1 to 7, 6 in. deep. Joints as close as can be made. Asphalt in joints to 4 or 5 inches of surface, rest grout. No laths. Blocks 6×3×7, 8, and 9. Never used beech or elm.	No.	10/- to 12/- where the roadway is macadam, including excavating away old material, and laying concrete.	7 to 10 years. Where the road would be misleading to answer, but generally ½ in. to ¾ in. sometimes more. Heavy traffic.	No.	Varies with traffic and other circumstances from -/8 to 1/- per yard.	About 2d. to 3d. under heavy traffic in great thoroughfares.	If asphalt is properly kept it will outlast nearly as much as wood, but as a rule, asphalt is least cost.
8	Leamham	—	No wood laid, unless a few yards in Blackheath Village.	—	—	—	—	—	—	—

9	Hackney	-	No wood laid.
10	St. Giles	-	Wood pavements have been laid in various carriage-ways from time to time in St. Giles's District, having a total length of little over a mile; but as the several lengths have been worn out, the wood has been lifted and compressed asphalt laid down. Concrete used—1 of cement or blue lias lime to 6 of ballast. For further particulars see report.
11	Chelsea— (Geo R. Strachan, C.E.)	50,131	Plain blocks, cement joint, concrete foundation. Blocks second quality yellow deal. Portland cement concrete, 6 in. thick—5 of ballast 1 sand, and 1 cement, topfloated with 3 to 1 cement grout. 3 studs Portland cement girth—2 to 1 clean sand and cement, $\frac{1}{8}$ -in. joint. Beech blocks, wear very well, better than deal; but they give an unpleasant vibration. Blocks 9x6x3. <i>Remarks</i> —The principal point is to get a thoroughly good foundation. The blocks are really a wooden carpet on the real road—the foundation.
12	St. John, Clerkswell	-	No wood pavement.
13	Woolwich	-	No wood pavement.
14	Croydon	-	No wood pavement, but two trial bits.
15	Herford	-	No wood pavement.
16	Birkenhead	-	No wood pavement.
17	Darby	Half-a-mile.	Three systems have been tried—viz., Asphalt Wood Paving Co.'s, the Improved Wood Paving Co.'s, and Messrs Armstrong, Addison & Co.'s, Sunderland. Portland cement concrete, 6 in. thick, 1 part of cement to 4 of broken stone, $\frac{1}{8}$ -in. joints, grouted with boiled pitch and creosote. Laths used in the portion laid by the Improved Wood Paving Co. Blocks 9x6x3. Beech, elm, and redwood were used.



*SCHEDULE—continued.*

	Name of City, Town, Vestry or Parish	Area in yards super- ficial	What plan of Pavement is adopted? If by Contract? Quality of Timber? Description of Foundation? Breadth of Joints? How Grouted? Are Laths used? Size of Blocks? If Beech is used?	If new Pavement has been ever laid without concrete bottom, or on old bottom under macadam	Cost per yard superficial	Life and Wear of Blocks	Opinion of Medical Men as to Wholesomeness	Cost of Maintenance	Cost of Scavenging per yard superficial	Cost of Scavenging Wood as compared with the best Set Paying
18	Worcester -	-	No wood pavement unless that laid by tramways. Beech blocks 9x4½x3, saturated with 10 lbs. of creosote oil per cube foot, on a foundation of Portland cement concrete, 6 in. thick, 4-in. joints, with asphalt poured in hot. Laths used.	-	About 13/-.	Down about 2 years, showing no sign of wear except where joints are rounded off from being laid too wide.	-	-	-	-
19	Lincoln -	-	No wood pavement.	-	-	-	-	-	-	-
20	Bury -	4,300	Laid by Corporation. Creosoted blocks on 6 inches of Portland cement concrete, composition 7 to 1, top grouted. Beech and fir blocks 6x3, the joints to 1½ inches of top filled with pitch and pea gravel, and completed with cement grout, 8 to 1. Beech wears well.	No.	Paid for Beech-wood, 8/6 per yard, labour and other materials cost 3/-, 12/- complete; Contractor paid 15/- and 8d. for maintenance.	Fir blocks still down 8 years, with occasional repairs. Beech laid 4 years, no sign of wear.	No.	-	-	-
21	Chester -	-	No wood pavement.	-	-	-	-	-	-	-
22	Wolverhampton -	-	No wood pavement.	-	-	-	-	-	-	-
23	Sunderland -	2 miles of main thorough-fares.	Fir and beech upon Portland cement concrete foundation, run with pitch and gravel. Mergol is used, 6 in. deep, 3 in. wide, 3 in. to 11 in. long. English beech for tramways; it is more durable than fir, but more slippery. Foundation Portland cement concrete, 6 to 1 of local ballast. 4 in. laths from side to side. Butt joints close. Grout—pitch mixed with creosote oil and small gravel. Joints 4-in.	No.	11/9 complete.	First street (Bridgstreet) laid down 12 years, had one side turned from end to end last year. In 1879 there were 1,727 measurements taken showing the average wear 9/16 in.	No.	About 2/6 per yard taking up and relaying—cost per year therefore, 2½d.	-	-

					11/0 contract price.					No. data.	No. data.	
24	Oldham	-	1,000	The Improved Wood Paving Co. Laid 1880. Red creosoted. Lime concrete foundation, 6 in. deep. Laths are used. Joints grouted with asphalt. No beech laid.	-	-	Not ascertained.	-	-	-	-	No. data.
25	Rochdale	-	-	No wood pavement laid by Corporation. The Tramway Co. were compelled to lay down some on each side of the Town Hall, and all places of worship along their line. Concrete foundation 6 in. deep, 6 to 1, floated up. Joints about $\frac{1}{4}$ in., filled with asphalt. Blocks 6x4.	-	-	Only laid 3 years. No apparent wear.	-	-	-	-	-
26	Bradford	-	10,000	Ordinary redwood Concrete foundation, 6 to 1, and 6 in. deep, floated to a smooth surface, upon which the blocks are laid directly. Laths used in work, but are drawn out. Joints about $\frac{1}{4}$ inch, grouted with asphalt.	No.	12/6, including foundation blocks 3x6, 14/9 per 100, or £7 7/8 per 1,000.	6 to 8 years as traffic is greater or less, wear 1 to 1 1/2 in. 6 years heavy traffic.	-	-	-	-	-
27	Manchester	-	-	Laid only to a limited extent. The first system on elm boards, which proved a failure, recently laid with a concrete foundation, with $\frac{1}{4}$ in. of sand, and asphalt grout in joints. Hydraulic mortar—5 of broken stone to 1 of lime, as foundation. Joints about $\frac{1}{4}$ inch.	No. This would be most unsatisfactory, as the macadam has a tendency to retain the moisture which seriously affects the wood.	14 1/4 in one instance, 12/11 1/2 in another.	-	No.	It is impracticable to do much repairs—better to make a substantial job in first instance, then when wear begins repairs will be placed together.	-	-	-
28	Crewe	-	-	No wood pavement.	-	-	-	-	-	-	-	-
29	Leicester	-	4,250	A system similar to that in practice by Mr. Haydon, Surveyor, of Chelsea.	Where an old wood pavement was taken up which had been laid on boards, the cavity which was increased by a greater crown given to the road was filled with 2 to 3 in. C. concrete.	6/3 to 7/1 including in lime concrete foundation.	After 9 years found some blocks worn 1 1/2 inches, others fit to be re-used in crossings, &c.	No.	-	-	-	-
30	Blackpool	-	-	No wood pavement.	-	-	-	-	-	-	-	-

*SCHEDULE—continued.*

	Name of City, Town, Vesry, or Parish	Area in yards super- ficial	What plan of Pavement is adopted? If by Contract? Quality of Timber? Description of Foundation? Breadth of Joints? How Grouted? Are Laths used? Size of Blocks? If Beech is used?	If new Pavement has been ever laid without concrete bottom, or on old bottom under macadam	Cost per yard superficial	Life and Wear of Blocks	Opinion of Medical Men as to Wholesomeness	Cost of Maintenance	Cost of Scavenging per yard superficial	Cost of Scavenging Wood as compared with the best Set Paving
31	Halifax	-	No wood pavement.	-	-	-	-	-	-	-
32	Salford	-	No wood pavement.	-	-	-	-	-	-	-
33	Nottingham	15,000	Crescoted and uncrescoted red deal, also crescoted beech, on a Portland cement concrete foundation, about 8 to 9 inches deep, in the proportion of 1 to 3 of broken bricks and 5 of Trent shingle and sand. Blocks 3X3 and 3X6, 4-in. joint, grouted with asphalt.	Wood pavement was never laid except on a concrete founda- tion.	11/6. Beech costs about 2/6 more than crescoted red deal.	Under the great- est traffic cresc- oted red deal, 5 in. deep, lasted 7 years. Beechwood blocks have only been tested 2 years under heavy traffic, but be- lieve they will wear much better than crescoted red deal.	-	-	-	
34	Newcastle-on-Tyne	7,500	900 yards first laid with pitch pine, and 6,800 with crescoted beech blocks, 6 in. deep and 3 in. wide, which are wearing fairly. Portland cement concrete foundation, of 6 in. clean gravel and sharp sand to 1 of cement. The laths used are drawn out. 4-in. joints with asphalt.	No.	13s. including concrete, £7/10 per 1,000 blocks.	-	No.	3d.	-	-
35	Hull	6,150	Crescoted blocks on concrete founda- tion. Redwood blocks in all places but one street. Beech laid in one street; its wear was not such as to lead to its being used again. Port- land cement concrete, 7 in. deep, of 5 parts to 1, faced with 4-in. cement and sand, of 3 to 1 proportions. Laths used. 4-in. joint, filled with asphalt to 1 inch of top, remainder with cement. Blocks 9X6X3.	No.	7/3, using old foundation for making con- crete.	-	No.	-	-	-

36	Swansea		No wood pavement.	No	Last contract was for concrete and blocks complete, 9/8 per yard. Company maintain this, 1 year free, and 30 years at 9d. per yard per annum. Blocks per 1,000, £7/5	5 years.	No.	As stated, except connection with tramways, which is 1/- per yard.	
37	Birmingham		The Improved Wood Paving Co.'s for the bulk. Red deal. Portland cement concrete, 6 in. deep, composed of 5 measures of slag (No. 2 gauge), 2 of washed sand, 1 of cement. Laths used to be placed in interstices. Joints, as a rule, filled with asphalt. Blocks 3x6x8. No beech or elm. Pitch-pine used in one street only, against tram metals.	In one street the bottoming was not disturbed when granite sets were removed, but a coating of concrete spread to form proper level.	16/- in one street. When relaid by Corporation men blocks were delivered at 15/- per 100, plain, and 16/- on both sides.	5 to 7 years. Pitch Pine laid July, 1889, lifted August, 1888, worn 1 1/2 to 1 1/4 in. heavy traffic.	No.	Repair just means renewal in the case of wood pavement.	
38	Glasgow	5,655	Lloyd's system. Blocks grooved on side, laid upon thin coat of sand upon top of concrete. Blocks also laid direct upon the concrete, and portion on wood planks placed over concrete, and tarred. Pennycuik pitch-pine and white blocks, 8x6x2. Foundation Portland cement concrete - 1 of cement, 3 of broken stone, and 1 of sand, laid 4 in. to 6 in. (6 in. now always adopted). Laths inserted, but removed before grouting with asphalt. 1/2-in. joints. No beech or elm.	No.	About 14/- complete.	About 7 years. If light traffic it might stand 12 or 14 years. Queen's Ferry street worn out in 7 years, was replaced with stone.	Objected to as slippery, soft, and sloppy in wet weather.	Say first 5 years free, afterwards 1/3 per annum.	
39	Edinburgh	9,088	Redwood blocks 7x3, on 6 in. of Portland cement concrete - 5 of stone to 1 of cement. Studs in blocks. 1/2-in. joints grouted with asphalt.	No.					
40	Yarmouth	11,000	Portland cement concrete - 6 in. shingle, 1 sand, 1 cement, as foundation. Memel blocks 8x9 and 3x11, 4 1/2 deep. 1/2-in. joints. Tar run into joints. No beech or elm.	No.	7/4 to 8/-	2 years laid, none taken up.	No.		
41	Bolton	1,612	As an experiment only. Blocks of best Swedish yellow deal, paved close together. Foundation Portland cement concrete - 1 to 6 of gravel. No studs, laths, or felt in joints, which are as close as can be made. Asphalt grout. No beech or elm.	No.	12/- per yard complete. 5/8 superficial yard plain 7/- cross-cut.	Nones taken up.	No.	Scarcely anything yet.	

*SCHEDULE—continued.*

Name of City, Town, Vestry, or Parish	Area in yards super- ficial	What plan of Pavement is adopted? If by Contract? Quality of Timber? Description of Foundation? Breadth of Joints? How Grouted? Are Laths used? Size of Blocks? If Beech is used?	If new Pavement has been ever laid without concrete bottom, or on old bottom under macadam	Cost per yard superficial	Life and Wear of Blocks	Opinion of Medical Men as to Wholesomeness	Cost of Maintenance	Cost of Scavenging per yard superficial	Cost of Scavenging Wood as compared with the best Set Paving
42 York	7,440	First pavement laid was of cross-sliced blocks, 9x6x4, on a Portland cement concrete foundation. Paving laths 1x4. Joints filled with checkers from gravel, and run with asphalt. Present system blocks 9x6x3, dipped in hot pitch and tar when being laid. A layer of asphalt placed over the concrete bottoming. 4-in. joints, filled as formerly. Blocks adhere to the asphalt bed. Fir and beech used. Small area of beech laid; is wearing fairly well.	No.	12/6 formerly, 8/9 for the last done. Foundation and excavation 3/- per yard extra. Blocks (9x6x3) 6/6 per superficial yard.	None worn out yet, wear 4 in. after 9 years medium traffic.	No complaint yet.	No repairs yet.	—	—
43 Sheffield	4,000	About 600 yards were laid by the Asphalt Wood Pavement Co. Best redwood—St. Petersburg deal—on a foundation of Barrow lias lime concrete, 6 to 1 generally. 4-in. laths, temporarily laid. Pitch and tar grout to 2 inches of surface, then covered with hydraulic lime grout. Blocks 8x6x3. No beech or elm.	No.	Asphaltic Wood Co. 16/-, with our own men about 10/- Blocks, £3/6 per 1,000.	A portion down 6 years, relaid, showed nearly 1/2 of block worn away.	No.	—	—	—
44 Carlisle	—	No wood pavement, but 200 yards.	—	—	—	—	—	—	—
45 Cambridge	—	No wood pavement.	—	—	—	—	—	—	—
46 Oxford	—	No wood pavement.	—	—	—	—	—	—	—
47 Dover	—	No wood pavement save an experimental piece in front of the hospital.	—	—	—	—	—	—	—
48 Portsmouth	—	No wood pavement.	—	—	—	—	—	—	—
49 Rotherham	—	No wood pavement.	—	—	—	—	—	—	—
50 Belfast	180 in length.	This was laid in 1872, and removed in 1877, and Welsh granite substituted. It was done by the Tramway to prevent noise. Foundation of concrete, 6 to 1. The blocks were laid on the improved wood pavement plan, as well as I can make out.	—	—	—	—	—	—	—

# WOOD PAVING.—Return, of the Cost, Condition, &c.

Locality	System	What Repairs, and when	What Repairs now required
Margaret-street and Prince's-street	Blocks laid on cement concrete and grouted with lime grout	Margaret-st. paved with new blocks in May, 1882. Prince's-street relaid with best of the old blocks	None
Mortimer-street by Mid. Ho. and Berners-st.	do.	Some small repairs during 1881	Thorough repair especially toward Cleveland-street
Stratford-place Mews ..	do.	A few yards of decayed blocks removed and new substituted in 1881	None of importance
Oxford-street, between Portman-street and west end of Hereford-gardens	Blocks laid on cement concrete joints partly filled with asphalt and grouted with lime grout	Some repairs along the centre in February, 1881, with 5-inch blocks. Repaired generally along the centre in April, 1881.	General repair principally along the centre
Oxford-street, Prince's-street to Marylebone-lane	A foundation of cement concrete covered with tarred felt, on which blocks are laid, with a layer of felt also in the longitudinal joints, and the whole grouted with pitch and tar	In August, 1879, in the months of April, September, and December, 1880; in January and April, 1881, general repairs; in 1882, general small repairs	New wood block throughout
Oxford-street, Hereford-gardens to Edgeware-road	do.	do.	do.
Oxford-street, Duke-street to Portman-st.	do.	In Dec., 1880, Jan. & July, 1881, general repairs, principally along the centre. General small repairs in Oct., '82	None of importance
Mill-hill Place ..	do.	None .. .. .	None
Orchard-street ..	Blocks laid on cement concrete covered with a layer of asphalt the joints are partially filled with asphalt and grouted with lime grout	Small repairs in Nov., 1880, and none of importance since. Repairs in Oct., 1882.	
Oxford-street, from Marylebone-lane to Duke-street	do.	Oct., 1878, Aug., '79, Mar. and Oct., '80, general repairs, principally along the centre. In Nov., '80, intersection by James-st. was paved with new blocks. In Jan., '81, large area on north side east of James-st. was renewed. In Sept., '81, extensive repairs between Gees-court and James-st. principally along the centre. Renewed with 6" blocks from James-st. to the Rest opposite Stratford-place, Nov., 1882	The portions renewed this year will probably require new block next year
Mortimer-street, west of Great Portland-street	do.	None of importance .. ..	Thorough repair if not renewal
Great Portland street, opposite the Chapel	do.	Some small repairs during the year 1881	Thorough repair, must soon have new blocks throughout
Marylebone-lane ..	Blocks laid on cement concrete and grouted with Portland cement	Repaired in 1882 .. ..	New wood block throughout
Oxford-street, east of Regent-circus	do †	General small repairs throughout and renewal of blocks on north side of Rest by Tottenham Court-road early in 1882	General small repairs
New Cavendish-street	do.	None .. .. .	None
Gloucester-place, by Upper George-street	do.	None .. .. .	None
Henrietta-street, by Cavendish-square	do.	None .. .. .	None
Edgeware-road, south of Chapel-street	do.	None .. .. .	None
Manchester-street, south of George-street	do.	None .. .. .	None
Wigmore-street ..	Blocks laid on cement concrete and grouted with blue lias lime	None .. .. .	None
Cleveland-street ..	do.	None .. .. .	None
Marylebone-road	do.	None .. .. .	None

\* This price does not include the cartage to the Stone Yard, or the cost of breaking up the old paving, &c.  
† An area of 140 sup. yards on the south side, at the junction of the old road.

Court House, December 16th, 1882.

H. TOMKINS, Surveyor.



# APPENDIX.

TABLES EXTRACTED FROM COLONEL HAYWOOD'S REPORT, DATED 17TH MARCH, 1874.

## ASPHALT PAVEMENTS.

TABLE IV.—*Showing Cost in Certain Streets.*

Situation	Description of Asphalt	Years maintain	First cost per square yard	Agreed cost of maintenance per square yard for term of contract	Total cost of pavement during con- tract term per sq. yd.	Average cost per sq. yard per annum
Cheapside and Poultry	Val de Travers Compressed	17	£ s. d. 0 18 0	£ s. d. 2 years free 15 years at 1s. 6d. .. 1 2 6	£ s. d. 2 0 6	£ s. d. 0 2 4½
Gracechurch-street	"	17	0 17 0	2 years free 15 years at 1s. .. 0 15 0	1 12 0	0 1 10½
Finsbury Pavement	"	17	0 16 0	2 years free 15 years at 9d. .. 0 11 8	1 7 8	0 1 7½
Moorgate-street	"	17	0 16 0	Do.	1 7 8	0 1 7½
Do.	Limner Mastic	17	0 16 0	Do.	1 7 8	0 1 7½
Lombard-street	"	17	0 16 0	Do.	1 7 8	0 1 7½
Corn-hill	"	17	0 15 0	Do.	1 6 8	0 1 6½
Mincing-lane	"	17	0 12 0	Do.	1 3 8	0 1 4½

Foundations are included, but no excavation. The pavements are to be left as good as new at expiration of contracts.



## WOOD.

There must have been more than two dozen different kinds of wood pavement tried in the city. They have been tried in streets of large and small traffic, and subject to almost every condition which destroys a pavement thereof. The Commission has experience of its own both as to the durability and cost of wood.

## WOOD PAVEMENTS.

TABLE V.—*The Actual Duration and Cost of Certain Streets.*

Situation	Date when laid New	Life	First cost per yard	Total cost of repairs per square yard during life	Average cost per square yard per annum
		YRS. M.	£ s. d.	£ s. d.	£ s. d.
Corn-hill	May, 1855	10 2	0 12 2	0 17 4½	0 2 11
	July, 1865	6 8	0 11 6	0 8 9½	0 3 0½
Gracechurch-street	Nov., 1855	11 7	0 12 8	0 17 1½	0 2 6½
	June, 1865	6 0	0 11 6	0 6 11	0 3 0½
Lombard-st.	May, 1851	9 4	0 9 6	0 6 0	0 1 7½
	Sept., 1860	10 7	0 9 2	1 0 2	0 2 9
Lothbury	May, 1854	12 3	0 12 6	1 8 4½	0 3 4
	Aug., 1866	6 1	0 12 6	0 3 5½	0 2 7½
Mincing-lane	July, 1841	19 1	0 14 4	0 13 4	0 1 5½
	Aug., 1860	13 0	0 9 2	1 2 6½	0 2 5½
Bartholomew-lane	May, 1854	12 3	0 12 6	0 17 5½	0 2 5½
	Aug., 1866	5 5	0 12 6	0 3 11½	0 3 0½
Concrete foundations are included, but no excavation.					

The average life of the streets of greatest traffic, about 9 years.

The average life of the streets of least traffic, about 11½ years.

## WOOD PAVEMENTS.

TABLE VI.—Showing First Cost and Tendered Cost per annum for maintaining certain Wood-paved Carriage ways in the City of London.

Situation	Date when laid	Name of Contractor	Years to be maintained by Contractor	First Cost per square yard	Agreed Cost of Maintenance per square yard per contract term		Total Cost of Pavement during contract term per sq. yard		Average Cost per sq. yard per annum	
					£	s. d.	£	s. d.	£	s. d.
King William-street ...	Feb., 1873	Improved Wood Paving Company	16	18 0	1 year free	15 years at 1/6 = 1 2 6	2 0 6	2 6½	2 6½	
Ludgate-hill ...	Nov., 1873	do.	16	18 0	1 year free	15 years at 1/6 = 1 2 6	2 0 6	2 6½	2 6½	
Portions of Great Tower-street and Seething-lane	Sept., 1872	do.	16	16 0	1 year free	15 years at 1/3 = 0 18 9	1 14 9	2 2	2 2	
Bartholomew-lane ...	Jan., 1872	Carey	No agreement	12 6						
Do.	Dec., 1871	Improved Wood Paving Company	3	16 0	3 years free	...	0 16 0			
Duke-street ...	May, 1873	Mowlam & Co.	5	15 8	2 years free	3 years at 1/- = 0 3 0	These pavements will, no doubt, last some years longer than the contract time of maintenance.			
Houndsditch ...	Not yet laid	do.	7	17 0	2 years free	5 years at -/9 = 0 3 9				
Do.	do.	Carey	7	13 6	2 years free	5 years at 1/- = 0 5 0				

All before they were removed had been re-laid over their entire surface, and some new wood introduced from time to time in lieu of that found too defective to relay.

The cost of five streets of greatest traffic, 2s. 7½d. per square yard, and of least traffic, 2s. 4½d. The cost of wood therefore larger than asphalt.

In wood pavement the cost of the foundation is included, but no excavation. Pavement at the end of each financial year to be in good sound condition.

TABLE VII.—*Showing the Duration and Cost of certain Asphalt and Wood Carriage Pavements according to the Tenders sent in by the respective Contractors.*

Situation	Description of Pavement	Years to be maintained by Contractor	Average Cost per sq. yard per annum	
ASPHALT :			s.	d.
Cheapside and Poultry	Val de Travers (compressed)	17	2	4½
Gracechurch-street ...	do. ...	17	1	10½
Finsbury Pavement ...	do. ...	17	1	7½
Lombard-street ...	Limner (mastic) ...	17	1	7½
Cornhill ...	do. ...	17	1	6½
WOOD :				
King William-street ...	Improved wood ...	16	2	6½
Ludgate-hill ...	do. ...	16	2	6¼
Portion of Great Tower-st. and Seething-lane	do. ...	16	2	2

*Granite pavement*—The Commissioners have never paid for maintaining granite pavements, but the necessary work to the granite has been done as needed.

*RETURN showing the Annual Cost of Maintaining the Carriage-way Pavements in some of the principal Thoroughfares of the City of London, from Report dated 24th January, 1882.*

### ASPHALT PAVEMENTS.

Name of Thoroughfare	Description of Pavement	Annual Cost of Maintenance per yard superficial
		s. d.
Bishop-street, within .. ..	Val de Travers	1 3
Cheapside, Poultry .. ..	"	1 6
Fenchurch-street, between Gracechurch-street and Railway-place	"	1 6
Finsbury Pavement and Moorgate ..	"	0 9
Gracechurch-street .. ..	"	1 0
Gresham-street .. ..	"	1 3
King William-street (narrow part) ..	"	1 3
London Wall .. ..	"	0 9
Moorgate-street, between Coleman-street Buildings and London Wall	"	0 9
Moorgate-street, between Lothbury and telegraph S.	"	1 0
New and Old Broad street .. ..	"	0 9
Paternoster-row .. ..	"	1 0
Queen-street, between Cheapside and Pancras-lane	"	0 9
Queen-street, from Plover-lane to Victoria-street	"	1 3
Queen Victoria-street, from Mansion House to Cannon-street	"	0 6
Threadneedle-street .. ..	"	1 3
Algate .. ..	Limner Asphalt	0 9
Corn-hill .. ..	"	0 9
Lombard-street .. ..	"	0 9
Mark-lane .. ..	"	1 0
Mincing-lane .. ..	"	0 9
Moorgate-st. Telegraph S. to Coleman-st.	"	0 9
Newgate-street .. ..	"	0 9
Fenchurch-street, eastern end ..	Société Française des Asphaltes	0 9
Kings-street, Cheapside .. ..	"	0 9
Prince's-street, part of .. ..	"	1 3
Philpot-lane .. ..	"	0 6
Milton-street .. ..	"	0 6

*RETURN showing the Annual Cost of Maintaining the Carriage-way Pavements in some of the principal Thoroughfares in the City of London, from Report dated January, 1882.*

## WOOD PAVEMENTS.

Name of Thoroughfare	Description of Pavement	Annual Cost of Maintenance per yard sup.
		s. d.
Aldgate High-street ... ..	Improved wood ...	1 0
Bishopsgate-street Without ... ..	do. ...	1 0
Barbican ... ..	do. ...	1 0
Holborn ... ..	do. ...	1 0
Jewin-street ... ..	do. ...	0 10
King William-street and Adelaide-place	do. ...	1 6
New Bridge-street ... ..	do. ...	1 0
St. Paul's Churchyard, west end ...	do. ...	1 3
St. Mary's-axe ... ..	do. ...	0 9
Walbrook ... ..	Mowlem's wood ...	1 9
Wormwood-street ... ..	do. ...	1 0
Fleet-street, west end ... ..	Henson's wood ...	1 0
Leadenhall-street, east end ... ..	do. ...	1 6
Minories ... ..	do. ...	1 6
Fleet-street, eastern half ... ..	Asphaltic wood ...	1 0
Queen-st., Cannon-st., & Upper Thames-st.	do. ...	0 10
Cannon-street ... ..	Carey's wood ...	1 6
St. Paul's Churchyard, south and east sides	Gabriel's wood ...	0 8

## GRANITE PAVEMENTS.

ABERDEEN GRANITE.					
		Inches		s.	d.
Cheapside	...	3 × 9	...	0	6 $\frac{3}{4}$
Poultry ...	...	3 × 9	...	0	9 $\frac{1}{2}$
Old Broad-street	...	3 × 9	...	0	3
Moorgate-street	...	3 × 9	...	9	3 $\frac{3}{4}$
Lombard-street	...	3 × 9	...	0	3 $\frac{1}{4}$

Colonel Haywood, in 1871, estimated the total cost per square yard of granite pavement in these thoroughfares, opining that the granite had remained there until thoroughly worn out, and distributing the first cost of the pavements over their duration, as follows:—

Situation			Average Cost per square yard per annum, including First Cost and Maintenance.	
			s.	d.
Cheapside	...	...	1	7 $\frac{1}{2}$
Poultry ...	...	...	2	9 $\frac{1}{2}$
Old Broad-street	...	...	1	0 $\frac{1}{2}$
Moorgate-street	...	...	1	4 $\frac{1}{2}$
Lombard-street	...	...	1	0 $\frac{3}{4}$

[5th May, 1886.]

J. A. F. ASPINALL, President,  
in the Chair.

DESCRIPTION OF A CREOSOTING YARD FOR RAILWAY  
PURPOSES. By W. GREENHILL, C.E.

[Plates VI., VII.]

At the amalgamation of the railways forming the Great Northern Railway of Ireland in 1876, the united Company decided that all sleepers to be used in the line should be creosoted, and that to ensure the work being efficiently performed they would erect suitable machinery and appliances of their own for the proper sawing, grooving, and creosoting of the timber to be used for sleepers on the line.

A level piece of ground, 700 feet long and 120 feet wide, containing about 2 acres, was obtained adjoining the goods yard at the Barrack-street Station, Dundalk, and was connected to it by a siding, along the entire length of one side.

For illustration the ground may be imagined to run north and south (Plate V.).

At about one-third of its length from the north end and in the centre of the width the sawmill and machinery are placed. Wooden posts were erected and a segmental felted wooden roof 100 feet long by 25 feet wide, erected upon them, and over the machinery; and as the blocks are delivered at north end of the yard, and after treatment are to be stacked at south end, the machinery is so arranged as to afford continuous progress from north to south, that is to say, the saw-bench first centre-cuts the block, the grooving machine next cuts the groove, and the sleepers are then sent south to be stacked for seasoning.

The sawbench was supplied by Messrs. Robinson of Rochdale, and is specially designed for cutting sleeper blocks up to 12 inches square, and is capable of taking a circular saw up to 48 inches diameter, but a 42-inch saw is always employed, the most suitable thickness being No. 11, B. W. G., with teeth at  $2\frac{3}{4}$ -inch pitch.

The feed is provided by means of a pitch chain sunk flush with surface of bench and a loose iron dog with a handle is inserted at the rere of the block which is then propelled forward at a proper speed.

When the saw jams or an iron spike is met with in the timber, the dog can instantly be withdrawn and progress of block arrested and serious injury to saw thereby avoided.

As numerous blocks are not rectangular but somewhat of a diamond shape in cross section an apparatus was found necessary to press the side of the block firmly against the "rase" or vertical guard and so ensure sawcut being parallel with the sides of the block to avoid sleepers of uneven thickness which would occur if the block rested flat upon the bench.

The small apparatus is as follows:—A long armed lever of short stroke and provided with roller is pressed, by means of a weight, against the side of the block just clear of teeth of saw so as not to compress the sawcut; the error in the squareness of the block is thus divided and confined to the sides of the sleeper, the top and bottom of sleepers being perforce cut parallel.

The saws are sharpened by ordinary files, but at certain periods have to be deepened when teeth become worn; this is done by the ordinary punching machine designed for the purpose. The use of elaborate emery-wheel machinery, with its high speed, does not seem advisable; the simplest method of sharpening gives the least trouble. The saw is run at about 800 revolutions per minute by a 5-inch wide double leather belting, driven by overhead counter-shafting, supported on wooden uprights. As the shaft is very straight there is no



vibration, and it is practically in equilibrium, as the driving belt from the engine is on the opposite side to the saw belting, and the pull of the two belts counteracts. The saw bench was lengthened to 30 feet with the view of sawing long logs and varied scantlings.

#### GROOVING MACHINE.

The grooving machine is also of Messrs. Robinson's make, and forms groove for base of flange rails by means of cutters revolving 2,000 times per minute, driven by 4-inch single belting. At this high speed the spindles and brasses have not needed any repairs after eight years' working, probably largely due to pressure being entirely upon the upper brass. The machine, when supplied, required the headstock which carries the cutter to be raised or lowered by the vertical handscrew according as the sleeper to be grooved was thick or thin. This method of grooving enabled the sleepers to follow each other quite closely, and the two men became very skilful at obtaining a uniform depth of groove, but the arrangement was subsequently altered so as to enable the headstock to raise or lower itself without attention, each sleeper being spaced at least 4 inches asunder to give room for headstock to adjust itself.

Boring machinery, with twisted augers, was supplied, but only used for a short time, as the adoption of the improved ragged dogspike (which cuts its own way without splitting the sleeper) enables holes to be entirely dispensed with, and a much tighter fit of spike ensured.

After sleepers are grooved two men deposit them upon the small bogies which run on the 2' 6" gauge sidings leading to all parts of sleeper yard, and four men then pile the sleepers to the height of 14 feet, one tier on edge and the next tier on flat, to ensure facility and rapidity of seasoning. The grooving machine is in charge of one man and his

assistant; they keep the cutters in proper order, grinding them slightly convex, so as to form the groove slightly concave, and so afford stability to the rail. The upper brass, in which runs the spindle to which the cutters are attached, is shown as an instance of durability. The pressure is constantly upon this brass, as the belts are overhead; and assuming that the machine is in use only four hours per day for the past eight years, the spindles must have revolved 1,400 million times, and have grooved one million sleepers; yet the wear of the brass is scarcely perceptible, though the tension of the belting must be considerable at the high speed of 2,000 revolutions per minute of the cutters.

#### RECEIVER AND APPARATUS.

The receiver was originally only 30 feet long (or 3 sleeper lengths), and of an internal diameter of 6 feet, and with door at one end only; it was lengthened to 60 feet (or 6 sleeper lengths), and is made of  $\frac{3}{8}$ -inch plates, single riveted. The plates of the length next to the mouth failed by reason of the great tension of the fastenings which secured the door, and new  $\frac{1}{2}$ -inch plates had to be substituted for that length of about 4 feet; so the receiver now represents just sufficient strength, and no more, as the single riveting would leak slightly now at pressures above 110 lbs. The safety valve is loaded to 110 lbs., but seldom or ever rises; it is, however, frequently lifted to let off air and water which float on top of the creosote when the pressure pumps are working. The tanks are six in number, made of ordinary spruce plank, 3 inches thick, and are sunk flush in the ground, the receiver resting upon them; each tank 10 feet long, 5 feet wide, and  $4\frac{1}{2}$  feet deep, joined to its neighbour by a short length of pipe. One vertical inch of the six tanks represents 156 gallons; so that if the charge of sleepers numbered 312, then each vertical inch would represent half a gallon of creosote injected per sleeper.

A vertical gauge, which rises and falls by means of a float, has thus been constructed, by which the number of gallons or pounds of creosote injected per sleeper is at once read off the scales of sheet brass attached to the gauge. When only a single charge of sleepers is creosoted per day no bogies are used, and the number of sleepers in a charge are 360 of  $10 \times 5$  and 440 of  $9 \times 4\frac{1}{2}$ ; but when two charges of the receiver are creosoted per day, then bogies are used, and the number of sleepers per charge is reduced from 360 to 288, and from 450 to 384, the lesser number, however, being doubled, and made 576 and 768 respectively. Through the tanks ordinary gas-pipes of  $1\frac{1}{2}$ -inch bore circulate, into which steam is admitted from the engine-boiler at about 60 lbs. pressure, and the temperature of the creosote thus raised to 120 degrees, whereby the naphthaline and other substances are dissolved, and the creosote made thoroughly fluid. Two force-pumps of 3-inch bore and 4-inch stroke were in use for some time, though the receiver had been doubled in length; however, one of these pumps was removed, and one of 4-inch bore with the same stroke substituted.

These are found ample to supply the 60-foot receiver. A pressure too rapidly applied makes the receiver leak. About three hours of steady pressure are required to force the oil well into the wood. Receiver is filled by means of an air pump,  $6\frac{1}{2}$  inches diameter, 10-in. stroke, which exhausts the air. Communication is previously opened with the creosote and the pressure of atmosphere forces the oil up into the receiver. When the gauge glass shows receiver to be nearly full the valve is shut, air pump stopped, and force pumps are set to work. Air pump runs up the receiver in 20 minutes, and is believed to give less trouble than steam ejectors. Air pump does not extract the sap as some suppose—the partial vacuum has no effect on the timber. Six bogies of an iron frame upon 4 wheels convey the sleepers into receiver, and at busy times when days are

long two charges per day are creosoted as six bogies are being loaded with sleepers, while the other six bogies are inside the receiver—two sets of bogies are thus necessary.

To avoid the trouble caused by the buoyancy of the sleepers lifting the wheels off the rails a deep-ribbed angle-iron  $5'' \times 5'' \times \frac{3}{8}''$  forms the rail inside the receiver, and the bogie wheels run on their flanges in the corner or angle of the angle-iron, so that the vertical rib acts as a check rail, and with as much flotation as four inches the wheels regain their proper position.

Owing to the space occupied by the bogies the number of sleepers in a charge must be reduced, but at Dundalk the reduction is only 15 per cent. to 20 per cent., which is believed to compare favourably with other yards.

#### CREOSOTE,

Meaning "flesh preserver," is an unsuitable designation apt to be confounded with the acid present in wood smoke which preserves or cures flesh. Creosote is an oily dark liquid of complicated composition, varying with the quality of the coal, from which it is obtained; several of its components are anti-septic, chemically or mechanically. It was lately considered suitable when of light specific gravity; but experience proves that this light oil is volatile to some extent, and also soluble in water, so that exposure to rain washes out the valuable acids and the timber appears as if it had never been creosoted. With the heavy oils well heated, and with the use of high pressure a better result is obtained, the naphthaline is dissolved by the heat, and afterwards fills the pores of the wood and then solidifies. Specific gravities of creosote vary with the locality in which it is distilled.

		Maximum	Minimum	Mean
Dublin Oil -	-	11.05	10.35	10.64
North Wales Oil -	-	10.57	10.35	10.45

These means approach closely to the approved average of 10-50.

Carbolic acid is now regarded as of secondary importance, owing to its volatility and solubility.

Dr. Tidy's specification for creosote is here summarized:—

1. To be quite liquid at 100 degrees Fahrenheit, without deposit until temperature falls to 95 degrees.

2. One-fourth not to distil over in a retort at less temperature than 600 degrees, and this fourth to be heavier than water.

3. To contain 8 per cent. of tar acids by analysis with caustic, soda, and sulphuric acid.

4. No bone oil or shale oil, or any oil not distilled from coal tar.

The contracts for supply of the necessary annual quantity of creosote—about 250,000 gallons—is let at the beginning of each year, and the oil is received by the company in quantities weekly, according to requirements. The casks hold from 36 to 38 gallons each. The specific gravity of the oil is carefully obtained by hydrometer; the weight of each cask, when full and empty, is taken to ascertain, by tare and net, the total number of gallons. Consumption of oil varies from 140 to 180 casks per week.

#### TIMBER.

The sleeper blocks usually arrive in steam vessels, and are discharged and carted by the contractor from the quays to the creosote yard, where the company accept delivery, after examination, and when stacked—the contractor's men piling the blocks seven tiers high—but all blocks which have to be stacked a greater height are piled in position by the company's men. The total height of fourteen tiers is found most convenient.

When a cart arrives at the yard entrance with its load of

seven blocks, a favourable opportunity is afforded and utilised for examination of quality of the timber. Defects are numerous and varied, such as—shortness in length, and errors in scantling, excessive wane, iron spikes, decay, old blocks mixed with new, longitudinal shakes, dead knots, cup shakes ; sides of block appearing sound, but a small defect at end discovering the whole heart to be rotten. Very large knots 18 inches from end of block are objected to, as spikes would split such sleepers. The defective blocks are then marked with a stripe of paint of particular shape to indicate the description of defect, and then stacked separately in a place set apart, and are only sawn in two at express request of contractor, at his own risk of acceptance or rejection.

Very little seasoning or drying is found to take place in blocks when stacked too closely for air to circulate. When sawn the sleepers are stacked one tier on edge and next tier on flat, 150 sleepers to a pile. This yard of  $2\frac{1}{2}$  acres has a capacity for producing about 80,000 sleepers per annum. Beyond that number the area of stacking ground is insufficient, unless the sleepers are removed immediately they are creosoted.

About nine months seasoning is customary, but longer is desirable so as to insure dryness, as creosote and water are of such opposite natures that whichever is first in possession of the timber holds its place against the other, and in spite of all attempts to dislodge it. For instance, little or no creosote can be forced into a thoroughly wet sleeper, even at high pressures, and a thoroughly dry sleeper will readily absorb a large quantity of oil, which, when solidified by exposure to the air, no moisture either from rain or wet ground, will succeed in removing.

Good seasoning is necessary, as it is only “sappy” and “immature” timber that is obtainable at sufficiently low prices to repay the expense of the artificial means of preserving it

from decay by the process of creosoting. It is also however probable that seasoned heartwood, which might last a century if kept dry and protected from the weather, would rapidly decay without some preservation if it were exposed to all weathers, when buried in the ground like railway timber.

#### THEORY AND PRACTICE OF CREOSOTING.

In the vegetable as in the animal kingdom, the law seems to hold good that those fluids which are the chief support of the body during life, are the very first to attack and destroy it after death, and often very rapidly. Thus, the sap which absorbs carbon from the atmosphere, and by deposit of same in its descent of the tree enlarges the stem, is the very substance that, after the death of a tree by being cut down, becomes decomposed itself into its chemical constituents, which then attack and destroy the woody fibre, and render it brittle and weak, and unfit for use. The object of creosoting is to prevent this incipient decomposition, and creosote in a liquid form is convenient for being forced in and between the layers of woody fibre; the oil also penetrates the layers more or less, by means of the high pressure employed.

It is scarcely necessary to state that creosoting does not improve timber, but merely preserves it. Timber possessing serious radical defects retains them after creosoting just as much as before, and such timber should not be creosoted. The effect of creosoting is both mechanical and chemical. Chemical in its antagonism to vegetable decomposition, and mechanical in filling the pores of the wood, and thus excluding moisture and air, and becoming a kind of internal painting.

The class of timber generally subjected to creosoting is the red pine and spruce. With pitch pine a difficulty occurs owing to the large amount of resin, so that not more than one-third as much creosote can be forced into pitch pine as into red pine or spruce, at a given pressure—indeed, it is

very questionable whether an increase of pressure would result in any great increase in the quantity of creosote injected, as the resinous matter is so dense as to impede the introduction of the oil except at such pressures as are expensive and dangerous.

The most suitable quantity of creosote to inject is chiefly a matter of judgment and experience, and varies with the quality of the timber.

To force in too much oil would be waste, and too little oil would cause a risk of decay to timber.

In most cases the quality of the timber decides the uncertainty, as sappy timber absorbs more oil than mature timber, which has less necessity for it.

An average of 25lbs. weight of creosote injected is aimed at, equal to 8lbs. per cubic foot of timber.

With such an excellent material as pine timber—possessing three times the tenacity of wrought iron (weight for weight), facility of workmanship, and other valuable properties, it seems strange that the process which science has shown us can be adopted to prevent decay should not be more extensively adopted.

It is quite possible after some deodorising process to remove the pungent and unpleasant odour, that creosote may be used to preserve timber intended for concealed situations in dwellings and large buildings, such as floor-joists, wall plates, skirtings, rafters, &c., and render such impervious to worm or dry rot, or insect vermin. By utilising the present apparatus the cost would not exceed sixpence per cubic foot, as a separate set of tanks would only be required for the specially refined oil.

Creosoted timber must not be used where it comes in contact with breadstuffs, or comestibles of any kind, as in floors of warehouses where flour and such goods are deposited, as the strong flavour of the oil is sure to permeate them. As



an instance of creosote injuring drinking water, the author had occasion to secure a force pump down a well, and some sound old timber, creosoted 25 years ago, was utilised, but all had to be removed (owing to the flavour imparted to the water), and new timber substituted.

The superficial area must be borne in mind when specifying the weight of creosote to be injected per cubic foot, as a solid log would not absorb the same quantity as if it were first sawn into boards, and the surface thereby much increased.

#### WORKMEN AND THEIR DUTIES.

The staff of men employed is as follows:—

One working sawyer and general foreman; one engine driver; one groover; one assistant to ditto; one stacker; three assistants to ditto; one timekeeper, steam raiser, watchman (counts and books sleepers, keeps accounts, draws stores); two men bringing sleepers from yard to receiver; two men at saw bench; four men bringing in sleeper blocks to saw bench; two men running sleepers from saw bench to yard; one creosoter; three assistants to ditto.

Taking all these men at full time, their wages amount to £2 17s. 10d. per diem, and for that sum of money 360 sleepers 10 by 5, or 450 sleepers 9 by 4½ are prepared, which is equal to a cost of 1·927 pence and 1·54 pence per sleeper respectively, for the labour of sawing, grooving, stacking, creosoting, superintendence, and keeping accounts of a supply of 95,000 sleepers per annum. This yard being practically complete in itself, the storekeeper of the Engineer's Department merely furnishing to the sawyer the list received from Engineer's office of the sleepers to be sent out in the half-year, and their destination.

The above figures—1·927 and 1·54—do not include sundry minor expenses, such as weighing creosote, loading and unloading casks, piling blocks to extra height, &c., &c. All

counting, keeping note of despatch of each instalment so as not to exceed the proper total number of sleepers to each station, booking same, weighing creosote, tare and net accounts of same, &c., &c., are kept by the staff of creosoting yard.

With complicated mechanical appliances the number of men could probably be reduced, but as the duties of the yard are various, the men are found serviceable when casks of creosote have to be unloaded from wagons, empty casks loaded, heavy bridge-timber handled, scantlings overhauled for examination, creosote weighed, rejected sleepers and sleeper blocks re-examined, &c.

## ACTUAL RESULTS.

The actual outlay and work performed in the twelve months of the year 1884 was as follows:—

Wages, - -	£1,069	equal to	2·5 pence per sleeper
Stores, repairs to machinery, &c.	261	„	0·6 „
Creosote, 221,149 gallons @ 3½d.	3,225	„	7·84 „
	<hr/>		<hr/>
	£4,555		10·94 „

for all expenses from the time the sleeper block enters the company's yard until the sleeper is out of the receiver and ready for use.

Sleepers creosoted, - -	51,815	10 × 5
	41,500	9 × 4½
	<hr/>	
	93,315	

Average quantity of oil injected is 2·37 gallons, equal to 24·90 lbs. per sleeper.

Actual outlay in the year 1885 was as follows:—

Wages, - -	£952	equal to	2·43	pence per sleeper
Stores, repairs to machinery, &c. -	216	„	·59	„
Creosote, 241,664 gallons @ 2½d. per gallon	2,517	„	6·43	„
	<hr/> £3,685		<hr/> 9·45	„

Sleepers creosoted, - -	57,446	10 × 5
	36,578	9 × 4½
	<hr/> 94,024	

Average quantity of oil injected was 2·57 gallons, or 27 lbs. per sleeper.

Creosote during 1885 was obtained at a considerably lower figure than in 1884, namely, 2½ pence per gallon, against 3½ pence for 1884, and this accounts for most of the total expense per sleeper.

A larger quantity of creosote per sleeper was injected, namely, 27 lbs., against 25 lbs. in 1884.

Total number of sleepers 94,024, against 93,315 in 1884.

Number of gallons of creosote used 241,664 gallons, against 221,149 gallons in 1884.

Creosoting large quantities of timber in sizes convenient for handling costs 3½ pence per cubic foot, but with small scantlings, and with bridge-timber requiring extra labour to handle, the cost needs to be taken at fivepence per cubic foot.

Under the heading of expenditure for stores the only interesting item is coal.

A Robey's semi-portable double-cylinder engine, with tubular boiler, is employed, of about 25 horse nominal power.

Consumption of coal is 7¾ cwt. per diem, costing 5s.; as

one-half is slack coal, the engine being sufficiently large for her work, enables inferior coal to be used.

#### SAMPLES.

The samples of timber shown are—

No. 1.—A piece of a sleeper of diamond section. This is half of a sleeper of 12"  $\times$  6" rectangular section, originally intended for a joint sleeper for bridge rails which were being laid down new, in the year 1856, between Newbliss and Clones, and it was grooved with the wide groove for that purpose; but before it was used, the company resolved to adopt rails of the flange section, with fished joints, which do not require a joint sleeper, and so these 12"  $\times$  6" sleepers were sawn in two longways by a diagonal flat cut, with the view of giving more bearing upon the ballast.

When the writer took charge in 1869 some thousands of these sleepers were in the line, but, owing to their peculiar shape, no amount of packing could prevent their turning round in the ballast, and that cause alone and not decay hastened their removal. They are now nearly all removed, but except for wear, they were so sound as to enable them to be largely used for repairs of fences along the line. Subjected as these sleepers were for nearly 30 years to cold and heat, dry and wet, and partially buried in the ground, they afford a good instance of the efficiency of the process of creosoting.

No. 2 sample is a piece of an uncreosoted Memel log which the writer put into a bridge only 16 years ago. The timber was of best quality, sawn all round, and free from sapwood, but yet it is much decayed and unfit to carry weight. Two other similar logs put into a bridge in same year as the sample, were removed three years ago by reason of decay.

No. 3 sample is a piece of an uncreosoted sleeper showing almost complete decay. It is almost the only one left of a large number that were put in the line only 12 years ago, but

most of which were removed a few years ago from failure of the timber.

No. 4 sample shows a piece of a similar sleeper to No. 3, but exactly opposite in its condition, being thoroughly sound.

To test the value of creosoting, some sleepers were put in a branch line 12 years ago, and one half were creosoted and one half were not. From these the samples 3 and 4 were taken, and they speak for themselves.

Larch timber was much in favour with railway companies some years ago, and such a high opinion was held of its durability, that the delay of seasoning and expense of creosoting were considered unnecessary; but of the tens of thousands of larch sleepers obtained by the writer, not one now remains. A branch line opened new in the year 1860, and laid for three miles with larch sleepers, was taken charge of by the writer only nine years afterwards, when all these sleepers showed signs of serious decay, necessitating their prompt removal. The other four miles of this line were laid with Baltic sleepers creosoted, of only 8"  $\times$  4" cross section. Most of these still remain in the line, and after 25 years' service show little or no signs of decay, the only fault being the small cross section and the consequent crushed condition of the wood and deepening of the groove, rendering the sleeper very thin under the rail, as shown by sample No. 5A. Considering that the timber is still sound in its twenty-sixth year, this sample may be taken as exhibiting the benefit of creosoting, as with such a small scantling the sleepers were, no doubt, numerously sawn from the sap wood in the upper part of the pine tree.

Sample 5B is a portion of an original creosoted sleeper out of the main line, and was two years longer in use than 5A, as it was put in during the year 1858, and is, therefore, 28 years old, but the timber is quite sound.

No. 6 sample is a piece of a rejected block centre cut at contractor's request, and shows the necessity for careful

examination of timber before acceptance by the company, as, although the outside is sound an inspection of end betrayed the signs of decay. If this sample had been creosoted decay would not have been prevented, as the process does not pretend to convert bad timber into good, the only result would have been to throw discredit upon creosoting owing to the rapid failure of the wood. Cases of this kind have been unfairly used as an argument of the ineffectiveness of creosote to preserve timber.

No. 7 sample is a section of an ordinary sleeper as accepted from contractor, showing the grain and quality of the timber, the tree of which was probably cut down in the winter of 1884.

No. 8 sample is a section of a creosoted sleeper showing penetration of the oil where sapwood exists. Where heartwood occurs the penetration is not so deep nor is it so necessary as at the other part of the sleeper.

#### TELEGRAPH POLES.

The writer has been favoured with the following information as to the latest system for preservation of telegraph poles for Government:—

Creosoting is universally adopted, all other systems having fallen into disuse. It is reported that to obtain the specified quantity of 10 pounds of creosote injected per cubic foot the fine skin which grows upon the pole just underneath the bark must be carefully removed by planing. Native larch and other timber is reported to have failed, and no other timber but Baltic redwood well seasoned and then creosoted is used.

All the sundry processes of treatment of timber with salts of zinc, copper, and mercury seem to have fallen into disuse owing to the corrosion of the receiver and apparatus by the materials employed, a defect not possessed by creosote, and also to the solubility in water.

Oil paint in many cases, when used out of doors, conceals rather than prevents decay.

The life of railway sleepers is materially influenced by the locality in which they are placed and the weight and frequency of the passing loads they have to sustain; and it is somewhat difficult, therefore, to determine with accuracy the comparative durability of creosoted and uncreosoted sleepers.

Judging from past experience, we shall not be far astray if we assume that the ordinary Baltic sleeper uncreosoted will not last more than eight or nine years under ordinary main-line traffic, and that after six years of its service the wood becomes so soft and spongy from decay as to afford but a very insecure hold for the spikes.

From what we have seen of the same class of Baltic sleepers well seasoned and properly creosoted, we may reasonably expect them to last twenty-four or twenty-five years under main-line traffic. If, however, we assume, for the sake of argument, that the average life of an uncreosoted sleeper will extend to ten years, and that a creosoted sleeper will not last more than twenty years, we arrive at the simple conclusion that the effect of creosoting is to double the life of the sleeper—in other words, by adding to the cost of an uncreosoted sleeper a further outlay of  $7\frac{1}{2}$ d. we double its commercial value. Taking this view, and working it out for a given length of line—say 100 miles single track, and allowing 1,836 sleepers to the mile—we have the following result as the cost of the sleepers during a period of 20 years. The sleepers are assumed to be of the ordinary rectangular section, 8' 11" long, 10" wide, and 5" thick— $1,836 \times 100 \times 2 \times 2s. 8\frac{1}{2}d. = £49,725$ , the cost of the two sets of uncreosoted sleepers during the 20 years, and  $1,836 \times 100 \times 3s. 4d. = £30,600$ , the cost of one set of creosoted sleepers during the 20 years, showing a reduction of

£19,125 in favour of creosoting, or a saving of nearly £1,000 per annum.

Seeing the perishable nature of timber, and the prospect of a scarcity of supply in the near future—owing to the enormous consumption—it is only prudent to consider now the best means of obtaining the greatest durability by some antiseptic process which has stood the test of time.

Sleepers constructed of thin steel plates, formed into various shapes, have been tried both at home and abroad, but it is questionable if their use has yet passed the experimental stage, as the effects of years of wear and tear have yet to be ascertained upon thin metal so liable to deterioration from loose rivets, cracks, and the wearing away at bearing surfaces.

In the event of the non-success of metallic sleepers, the result would be a sudden return to the use of timber, and consequent increased demand for that material, thus affording an additional reason for studying the best method of preserving wood, which, owing to its elasticity, has been found so suitable for railway purposes.

In conclusion, these few remarks and explanatory drawings are submitted to this Institution, in the hope that they may be of some interest to engineers and others connected with railways, and also to prove that the outlay by a railway company on a creosoting establishment is justified, and results in an efficient and economical system, by which permanent-way timber and other timber may be prevented from decay for very many years.

The PRESIDENT said—Mr. Greenhill's paper on Creosoting is of a very useful character, giving as it does not only the method of dealing with the sleepers, but also the cost of the work done.

The arrangements for sawing, grooving, and creosoting



sleepers seems to be very much the same at Dundalk as at Inchicore; but as there are some slight differences he would mention them, as they may be of interest.

They included in the cost of production the unloading and stacking of sleeper blocks 10 feet high when first delivered. The sawing and grooving is done in similar machines at a piecework rate.

The grooving machines were, he believed, the first of the pattern made, and were constructed by the same makers to their design. The yard is laid with a tramway of 2 feet gauge, which he thought had advantages over a 2 feet 6-inch gauge, while a 1' 6" would be better than either.

The sleepers when grooved are placed on bogies and run up to the creosote receivers, into which they are placed by hand. There are two receivers, each holding 360 sleepers.

They could get two batches of sleepers creosoted in each receiver per day, and he thought it was open to doubt whether it was cheaper to run bogies into the receivers. He altogether disagreed with the view that an air-pump is better than an ejector. The latter take nine minutes only to exhaust the receiver, and were fitted instead of an air-pump. The ejectors have been working for ten years, and have not, he believed, cost as many shillings for repairs.

The sleepers are all 9' 0"  $\times$  10"  $\times$  5", and the quantity of creosote injected is about the same as at Dundalk. As in illustration of Mr. Greenhill's remarks about wet sleepers not allowing the creosote to enter them, he might mention that putting a thoroughly dried and a wet sleeper into the same receiver resulted in the former absorbing 36 lbs. of creosote and the latter 23 lbs.

The cutting speed of the sleeper saws is 9,500 feet per minute, and of the cutters in the grooving machines 7,600 feet per minute. A better arrangement of gauge than that described by the author is one which shows the number of

gallons of creosote injected, irrespective of the kind of timber put into the receiver. It is arranged with a circular dial and two revolving hands like those of a clock. These hands are fastened by thumbscrews to an axle turned by a float.

Before the ejector is started one hand is fastened at zero on the dial, and as it revolves indicates the quantity of creosote gone into the boiler. A second circle of figures on the dial indicates the number of gallons to be forced. The second hand is then fastened on the axle to zero, and the forcing continued until that quantity is registered.

He gave a table (which will be found below) showing the quantity of creosote that can be forced into memel, pitch pine, red pine, and beech when cut into small dimensions. It also serves to illustrate the great difference there is in the absorbing power of different pieces of the same kind of wood, and also how much oil is afterwards lost by evaporation from the exterior of the wood.

He had found that Scotch fir paving blocks  $8'' \times 4'' \times 3''$  absorb 19 lbs. of oil per cubic foot.

Mr. Greenhill's remarks about the lighter oils which have been somewhat recently introduced into the market are of great importance, and taking very similar views he last year tried some experiments, of which he gave the particulars, which showed some of the peculiarities of the lighter oils, though they do not prove its want of power to preserve the timber impregnated with it.

Sixteen dried sleepers  $9' \times 10'' \times 5''$  were selected to be creosoted with heavy oil of 1.055 specific gravity, and 16 similar sleepers were selected for the light oil of .974 specific gravity. Each lot of 16 weighed 14 cwt. 0 qr.  $11\frac{1}{2}$  lbs.

When creosoted the 32 sleepers were carefully wiped clean of superfluous oil, weighed, and then laid flat on skids on the ground exposed to the weather. At intervals of two months and seven months they were re-weighed.

## CREOSOTE ABSORBED BY DIFFERENT CLASSES OF TIMBER.

*The samples were all creosoted at the same time in the same boiler. Temperature of oil, 52° Fahr. Pressure per square inch, 100 lbs. for 3 hours.*

No.	Timber	Dimensions	Weight when Cleaned	Weight when Creosoted	Oil absorbed per cubic foot	Mean absorption per cubic foot	Loss by Evaporation after 3 Months	Oil Retained after 3 Months	Mean
1	Red Pine	-	lbs. oz. 37 0	lbs. oz. 46 14	lbs. oz. 9 14	lbs. 11½	lbs. oz. 3 10	lbs. oz. 6 4	lbs. 8½
2	Do.	-	35 10	49 8	12 14		3 0	9 14	
3	Sawn Pitch Pine	-	40 5	47 4	6 15		3 8	3 7	
4	Do.	-	50 1	57 4	7 3	5½	4 4	2 15	4½
5	Hewn do.	-	43 13	46 8	2 11		4 0	0 11	
6	Do.	-	41 8	47 0	5 8		3 0	2 8	
7	Dantizo Fir	-	38 8	46 6	7 14		3 2	4 12	4½
8			41 0	48 2	7 2	7½	3 6	3 12	
9	Beech	-	45 0	63 0	18 8	18	5 8	12 8	12½

He then immersed them in a large tank of water, taking care to keep them below the surface, and running off the water one day each week for four weeks and putting in a fresh supply. The sleepers were then taken out and re-weighed.

They were finally placed on end, exposed to sun and rain for a further period of four weeks.

The sleepers were found to absorb 8·77 lbs. of the heavy oil per cubic foot, and 10·26 lbs. of the light oil.

The final result two months after immersion was that ·25 lbs. per sleeper of the heavy oil was lost, while 2 lbs. per sleeper of the light oil had been either washed or dried out. Looking at the two sets of sleepers on a hot day it was easily observed that the lighter oil was very volatile, and there is no doubt it is more soluble.

Whether its antiseptic properties are such as to preserve the timber as well as the heavier oils is a question which can only be answered by time.

Upon the table he had arranged a large number of specimens of pieces of timber creosoted under varying conditions, the labels they bear stating what has been done in each case.

These specimens are more in connection with Mr. Neville's paper on wood-paving, but are useful as showing the disadvantages of white deal, as it will not absorb creosote in any quantity.

The following short table shows some of the results, but an examination of the specimens is of greater interest:—

*CREOSOTE absorbed by red and white deals, when cut into short lengths, to illustrate the difficulty of getting the oil to penetrate white deal, and also the impossibility of getting Creosote to enter wet timber in any quantity.*

No. of Pieces	With Vacuum				Without Vacuum	
	Timber	Scantling	Cubic feet	Absorbed per cubic foot lbs.	Absorbed per cubic foot lbs.	Butalightly dried absorption per cubic foot lbs.
32	White deal from stock	6" × 9" × 3"	3	9.08	9.33	9.58
42		4½" × 9" × 3"	3	11.83	11.83	12.83
64		3" × 9" × 3"	3	13.58	13.58	14.08
14	Very wet	4½" × 9" × 3"	1	7.0	6.25	7.25
32	Red deal	6" × 9" × 3"	3	16.25	15.8	17.67
42		4½" × 9" × 3"	3	15.41	15.08	17.75
64		3" × 9" × 3"	3	16.5	16.0	18.42

Mr. GRIFFITH could not agree with Mr. Greenhill in his statement that "to force in too much oil would be waste" He believed that the best results would be obtained if every particle of moisture was removed from the timber and replaced by creosote oil. For the protection of timber exposed in sea water to the attacks of the worm 12 lbs. of creosote to the cubic foot of timber was often specified, but this quantity was very seldom got in. Good results could only be obtained by the method described by Mr. Greenhill if the timber was thoroughly seasoned. No vacuum would remove moisture, and if water remained in the timber the protection of the timber by creosoting would be very imperfect. In May, 1884, a very remarkable paper was read by Mr. Boulton before the Institution of Civil Engineers on "The Antiseptic Treatment of Timber," in which he described the method of creosoting

now adopted by his firm. The object of this method is to get rid of moisture, as part of the timber-preserving process, and without injury to the wood. To understand the process it must be remembered that the boiling point of creosote oils range between 380° and 760° Fah., at the ordinary atmospheric pressure, while water boils at 212° Fah. These boiling points are of course lowered by a vacuum. The wet timber is immersed in creosote, which is then heated to about 212° Fah. By this means the moisture in the timber is volatilized, and then drawn off by the air-pump in the form of vapour, while the heat being communicated through an oily medium does not injure the timber. As the oil cools it is drawn into the now empty pores of the timber; and Mr. Boulton has extracted by this process as much as 10 lbs. of water per cubic foot from wet timber, and replaced it by an equal volume of creosote, by the action of the air-pump alone. This process appears so rational that he, Mr. Griffith, believed it would supersede, before long, the method so clearly described by Mr. Greenhill.

Mr. MILLS said that the paper read that evening was specially interesting because all the facts and experience, regarding the timber referred to, and of the statistics of the work done, were such as had come under Mr. Greenhill's own personal notice. Amongst the most valuable papers submitted to any institution were those comprising a well authenticated record of facts, and when those facts referred to work done on a large scale, and not merely experimental trials, they became of increased value for reference or comparison.

Mr. Griffith had taken exception to Mr. Greenhill's remark that in creosoting railway sleepers "to force in too much oil would be waste," but it must be borne in mind that the duties allotted to a timber pile and to a railway sleeper were totally different. The principal, if not the only element of destruction

in a pile, was decay, and hence the reason why it should be well impregnated with creosote to render the decay as remote as possible. In railway sleepers there were two elements of destruction at work—one of them the decay of the timber, and the other the abrasion or wearing away of the wood itself from the constant pounding caused by the passing loads. This latter element of destruction they had seen clearly illustrated this evening in the samples of sleepers exhibited, where the seat of the rail had been pounded or worn down so deep into the wood as to leave too small a thickness of timber to carry the rail with safety. These sleepers had to be taken out of the road, not on account of decay, but because they were actually worn down too thin to be of service. They had done their duty well for a long series of years, and were perfectly sound when taken out. No increased quantity of creosote would have made them last longer, and any increased quantity of creosote would have been waste.

In his estimate of the comparative cost of creosoted and uncreosoted sleepers on 100 miles of railway for a period of 20 years, Mr. Greenhill might very fairly have added, in the case of the uncreosoted sleepers, a large item for expense in the renewal of the fastenings for the second set of uncreosoted sleepers, as it is well known that only a very small percentage of taken out spikes or crab bolts can be used again.

Mr. GREENHILL, in reply to the discussion, said that piece-work had not been adopted, as there might be a temptation to hurry on the work, and his experience was that creosoting should be particularly well done, and the oil well forced into the wood. With piece-work an inspector would have to be present to see this performed.

He had just been favoured with a copy of a "Report on the Preservation of Timber," as presented to the American Society of Civil Engineers, which stated that—

"There is no process of wood-preserving which, when well done, is better established than creosoting; but there is no process where more bad work has been done, either by design or ignorance."

And further—

"Force in enough of the creosote to accomplish the preservation of the wood, and make sure that its quality and strength are such as neither to injure the fibre by excess, nor yet so weak as to leave the timber unprotected."

The gauge described by the President for registering the quantity of oil injected per sleeper seems to give all the necessary information, and has no doubt had some years of trial and success.

Weighing two sleepers before and after creosoting to ascertain quantity of oil injected, needs that they are of average condition of dryness; but the mechanical gauge does better in registering average per sleeper of the whole charge.

With the "Ejector" Mr. Greenhill had not had experience, but, inquiring at places where it was in use, he was recommended to retain the air-pump, which has not done badly when the receiver can be filled in twenty minutes, although it has been doubled in length since the air pump was made. A considerable outlay could not effect much saving of time on the twenty minutes.

Messrs. Burt, Boulton and Haywood's manager at Grimsby says:—"I have twice tried ejectors, but could never get a satisfactory vacuum. Nothing can supersede a good air-pump with metallic packing for speed and efficiency. It would be interesting to know the reasons for the difference of opinion—possibly ejectors need a high pressure of steam.

Mr. Greenhill experiences the same difficulty of creosoting "spruce" timber as was pointed out by the President. He supposed it was due to imperfect seasoning, but thought there must be something in the nature of the wood. Being a



perishable timber much used, it needs a preservative. Quoting again from the American Society of Engineers—"The most conscientious treatment of spruce will fail to obtain uniform and reliable results."

Some time ago sleepers were carried into the receiver, one at a time, on men's shoulders; but the labour and delay were great. Six feet bore is scarcely room enough for a man with a sleeper on his shoulder, and in summer weather the atmosphere in the receiver is insupportable by reason of creosote vapours.

Bogies have been very successful, as the "raw" sleepers can be loaded at any part of the yard, and when creosoted deposited at any other part of the yard, and scattered convenient for loading a long train of wagons.

As 15,000 sleepers can be creosoted per month at Dundalk, a reduction of six men is effected when no new branch lines are being made, as all hands are put to creosoting only, the sawing being stopped.

When sawing is necessary the creosoting is stopped, the two operations not being carried on at the same time.

The President has mentioned the gauge of the small sidings about the yard. When curves are not sharp 2' 6" gives more stability than 2' 0". That is why 2' 6" was adopted, as 2' 0" would be narrow where blocks are laid across the bogies.

Mr. Griffith mentioned creosoting as applied to piles of piers.

To avoid attacks of marine worm, an excess of creosote, and preferably of the heavy oil well heated, seems least likely to become washed out.

While recommending heavy oil, it is well to specify an absence of "free" or "undistilled" tar.

Mr. Smith questioned the £1,000 per annum economy in the estimate of 100 miles; also that 3s. 4d. per sleeper was too high a price, and no credit given at 10s. per ton for old sleepers taken out.

On the other hand no expense was charged in the estimate for the cost of removal of old sleepers and their fastenings, collection of same, new crab-bolts necessary, old ones are never re-usable, &c.

Sleepers have cost more than 3s. 4d., but are now less, so the price given is an average.

With the reduction in the price of sleepers there would be still a considerable saving by preserving the timber—approaching closely the £1,000 per annum for a hundred miles.

[19th May, 1886.]

J. A. F. ASPINALL, President,  
in the Chair.

The discussion upon a "Description of a Creosoting Yard for Railway Purposes," by MR. W. GREENHILL, occupied the evening (see page 265).

# **Institution of Civil Engineers of Ireland,**

*ESTABLISHED 1835 (INCORPORATED BY ROYAL CHARTER, 1877),*

**35 DAWSON-STREET, DUBLIN.**

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## **ANNUAL REPORT OF COUNCIL, 1886.**

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**THE** Council in performing their usual duty of presenting their Annual Report wish to thank the Members for the marked increase in the number of papers laid before the meetings, and for the manner in which their Circular of last November has been responded to.

The following is a comparative statement of numbers of Members :—

	1885	1886	Decrease	Increase
Honorary Members,	4	3	1	—
Members,	133	135	—	2
Associates,	49	53	—	4

The decrease in the number of our Honorary Members is caused by the death, last December, of one of the oldest Members of this Institution, and some years ago one of the most eminent Engineers in Ireland. George Willoughby Hemans, the youngest son of Felicia Hemans, was Resident Engineer on the Dublin and Drogheda Railway when he was appointed to the post of Chief Engineer of the Midland Great Western Railway of Ireland. He afterwards became Chief Engineer of the Waterford and Limerick and many other Irish lines. He subsequently removed to London and practised there for several years, but was attacked by paralysis and thereby incapacitated for the latter portion of his life. He joined this Institution as Member in 1845, and was President in 1857, and afterwards continued as Member until 1880, when owing to his

state of health, the Institution transferred him to the class of Honorary Members.

As anticipated in last year's report, the balance to credit of the Institution, as will be seen by the accounts appended, has continued favourable, although the year's accounts show the charge for Vol. XV. of the Transactions, and a £50 debenture has been paid off.

The awards made by the Council during the year were—

A Mullins' Silver Medal to past Vice-President, James Price, for his paper, "The Shortest Route to India," read upon 1st April, 1885.

The Smith Premium to H. A. Ivatt, Member, for his paper, "Break-down Tackle for Railway Work," read 4th March, 1885.

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## DONATIONS, 1885.

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The Proposed Derwent Water Works. By H. T. CROOK, Assoc.M.Inst.C.E.  
Report of the Hornsey Local Board on Team Work. By T. DE COURCY  
MEADE, Assoc.M.Inst.C.E.

Dublin Main Drainage Outfalls. By J. P. GRIFFITH, M.Inst.C.E.

The National Geological Survey of Europe. By Mr. W. TOPLEY.

Presidential Address, Aberdeen, 1885. By B. BAKER, M.Inst.C.E.

Theory of Stresses in Girders. By B. B. STONEY, LL.D.

Heat and its Mechanical Appliance. The Inst.C.E.

Theory and Practice of Hydro-Dynamics. The Inst.C.E.

The Journal of the Society of  
Arts, 1885.

The Timber Trades Journal, 1885.

The Irish Builder, 1885.

The Engineer, 1885.

The Illustrated Science Monthly,  
1885.

The Builder, 1885.

The Contract Journal, 1885.

Presented by the Editors.

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The Volumes of Transactions are exchanged with the following Institutions, &c.

American Academy of Arts and Sciences.

Boston.

American Society of Civil Engineers.

New York.

American Society of Mechanical Engineers.

New York.

Canadian Institute.	Toronto.
Institution of Civil Engineers.	London.
Institution of Mechanical Engineers.	London.
Institution of Engineers and Shipbuilders in Scotland.	Glasgow.
Liverpool Engineering Society.	Liverpool.
Manchester Association of Employers, Foremen, and Draughtsmen of Mechl. Traders of Great Britain	Manchester.
Master Car-builders' Association.	New York.
Midland Institute of Mining, Civil, and Mechanical Engineers.	Barnsley.
North of England Institute of Mining and Mechanical Engineers.	Newcastle.
North Staffordshire Institute of Mining and Mechanical Engineers.	Stoke-on-Trent.
Ohio Institute.	Cincinnati.
Royal Engineer Institute.	Chatham.
Royal Institute of British Architects.	London.
Royal Geological Society of Ireland.	Dublin.
Smithsonian Institution.	Washington.
Sociedad Cientifica Argentina.	Buenos Ayres.
Society of Arts.	London.
Society of Engineers.	London.
Société des Ingénieurs Civils.	Paris.
Society of Engineers and Architects, and the Poly- technic Society of Norway.	Kristiania.
Surveyors' Institution.	London.
The Engineers' Club of Philadelphia.	Philadelphia.
The Franklin Institute.	Philadelphia.

# THE INSTITUTION OF CIVIL ENGINEERS OF IRELAND.

## STATEMENT OF ACCOUNTS

From 1st January to 31st December, 1885.

Dr.

Cr.

EXPENDITURE.	£	s.	d.	RECEIPTS.	£	s.	d.
To Rent of House, Taxes, Repairs, and Insurance on Furniture, &c. . . . .	115	2	8	By Balance Cr., 1st January, 1885, . .	175	4	1½
" Premium upon Life of Duke of Edinburgh, 1884, . . . . .	12	4	2	" Entrance Fees, . . . . . £9 9 0			
" Interest upon Five Debentures of £52 10s., at 4 per cent., . . . . .	9	9	0	" Annual Subscriptions, . . . . . 204 15 6	214	4	6
" Printing and Stationery, . . . . .	96	8	0	" Rents, . . . . .	130	0	0
" Postage and Incidentals, . . . . .	7	4	1½	" Dividends upon £1,172 8s. 3d., Mullins' Bequest for 1 year to 5th October, 1885, less Income Tax, . . . . .	34	1	6
" Salaries, . . . . .	50	0	0				
" Servants, Fuel, and Light, . . . . .	20	0	0				
" Tea & Servants, at General Meetings, . . . . .	10	19	10				
" Purchase of Books, Smith Premiums, . . . . .	6	15	3				
" Do Medals, Mullins' Bequest, . . . . .	0	15	6				
" Debenture on House, . . . . .	52	10	0	Dinner Club Fund . . . . .	0	15	0
Balance Credit, . . . . .	172	16	7				
£	554	5	1½	£	554	5	1½

We certify we have examined the above Accounts and the Vouchers thereof, and that we find them correct, leaving a Balance Credit to the Institution of One Hundred and Seventy-Two Pounds, Sixteen Shillings, and Sevenpence—£172 16s. 7d.

35 DAWSON-STREET, DUBLIN,  
30th January, 1886.

CHARLES GEOGHEGAN, } Auditors.  
THOMAS FITZGERALD. }

# LIST OF MEMBERS.



INSTITUTION  
OF  
CIVIL ENGINEERS OF IRELAND,  
*ESTABLISHED 1836 (INCORPORATED BY ROYAL CHARTER, 1877.)*  
35, DAWSON-STREET, DUBLIN.

JANUARY, 1887.

## COUNCIL.

### President:

JOHN P. GRIFFITH.

### Vice-Presidents:

KENNETT BAYLEY, | SAMUEL GEOGHEGAN.

### Other Members:

JAMES DILLON,	HENRY A. IVATT,
THOMAS FITZGERALD,	THOMAS S. MARTIN,
CHARLES GEOGHEGAN,	SAMUEL W. NUGENT,
SPENCER HARTY,	WM. WESLEY WILSON.

### Past Presidents:

WILLIAM ANDERSON,	ROBERT MANNING,
JOHN A. F. ASPINALL,	ALEX. M'DONNELL,
JOHN BAILEY,	WILLIAM H. MILLS,
CHARLES P. COTTON,	BINDON B. STONEY.

### Honorary Secretary:

JOHN CHALONER SMITH.

### Bankers:

ROYAL BANK.



Members are requested to inform the Honorary Secretary if any correction be necessary. Foreign Members are requested to give an Address in the United Kingdom, where Transactions of the Institution or other documents may be sent.

## HONORARY MEMBERS.

(*Hon. M.Inst.C.E.I.*)

### ELECTED

- 1861 Haughton, Rev. Samuel, M.D.,  
D.C.L., F.T.C.D., F.R.S., . 39, Trinity College, Dublin.
- 1868 M } Grubb, Howard,  
1882 H.M. } F.R.S., . . . . 141, Leinster-road, Rathmines.

## M E M B E R S .

(*M.Inst.C.E.I.*)

- 1856 Anderson, William, M.Inst.C.E.  
(*L.M., Past Pres.*), . . . Lesney House, Erith, Kent, S.E.
- 1869 Andrews, James, . . . 2, Charleville-road, Rathmines,  
and City Hall, Cork-hill.
- 1869 F.L.A. } Apjohn, Jas. H., M.A., M.  
1875 F.L.M. } Inst. C.E., (*L.M.*), . Public Works Department,  
Bengal.
- 1880 Armstrong, George A., . . . G. Northern Railway, Amiens-  
street.
- 1885 Armstrong, Robert C., . . . Umzinto, Alexandra Co., Natal
- 1877 Aspinall, John A. F., Assoc. M.  
Inst. C.E. (*Past President*), . Fernbank, Heaton, Bolton le  
Moors
- 1874 Atock, Martin (*Past Vice-  
President*), . . . . Royal Canal House, Broad-  
stone.
- 1880 Backhouse, Marmaduke, B.A., . 9, Harcourt-terrace, Dublin.
- 1865 Bailey, John, M.Inst. C.E. (*Past  
Pres.*), . . . . Boulogne, France.
- 1879 Banks, William, B.A. . . . 1, Leeson Park Avenue.
- 1876 A } Barnes, John F. Evelyn  
1879 M } (*F.L.M.*), . . . . Durban, Natal, South Africa.

## ELECTED

- 1874 <sup>A</sup> } Barrington, Edward, . . . 3267 N.-street, Washington  
1880 <sup>M</sup> } D.C., U.S.A.
- 1874 Barton, Folliott, . . . Cape of Good Hope.
- 1879 Bayley, Kennett, M. Inst. C.E.  
(Vice-President), . . . Great Southern and Western  
Railway, Inchicore.
- 1865 Beatty, John, . . . India.
- 1885 Bell, Walter F., . . . Braemar-terrace, Balmoral,  
Belfast.
- 1883 Birch, Edward Robert, Assoc.  
M. Inst. C.E., . . . Ravensdale, Dundalk.
- 1874 Brett, John H. (*L.M.*), . . . Co. Surveyor's Office, Belfast.
- 1879 <sup>A</sup> } Browning, Frederick, . . . 37 Wellington-road.  
1882 <sup>M</sup> }
- 1854 Byrne, Edward, M.Inst.C.E. . . St. Augustine, Cavendish Road  
Southsea.
- 1874 Carroll, Frederick Arnold, . . . 5, Up. Prince Edward's-ter-  
race, Blackrock, Co. Dublin.
- 1876 } Chappell, Henry, . . . Newtownards, County Down.  
1883 }
- 1865 Clark, George R., . . . Public Works Department,  
Darjeeling, India; and 15,  
North Richmond-street.
- 1884 Clarke, William F., . . . Esker House, Lucan.
- 1870 <sup>A</sup> } Cochrane, Robert, M.R.I.A. . . Board of Works, Athlone.  
1882 <sup>M</sup> }
- 1886 Comber, Patrick F., . . . 37, College-green and Friary  
Hall, Bray.
- 1865 Cooke, Theodore, M.A. (*F.L.M.*) . . . Poona, Bombay.
- 1861 Cotton, Charles P., M.Inst.C.E.  
(Past President), . . . Ryecroft, Bray; Local Govern-  
ment Board, Dublin.
- 1860 Crawford, Robt., M.E., M. Inst.  
C.E. . . . Trinity College, Dublin.
- 1883 Creery, Leslie, . . . Sligo.
- 1881 Crook, Henry T., Assoc. M.Inst.  
C.E. (*Past Vice-President*), . . . 9, Albert-square, Manchester.

REMOVED

- 1874 Crosthwait, John T., . . . Montreaux, Switzerland.
- 1881 Crowe, Oswald B., B.A. . . . Denis' quay, Kinsale.
- 1873 Denny, Robert, . . . Denny-street, Tralee.
- 1863 Dillon, James, M.Inst.C.E.  
(*Past Vice-President, Member of Council*), . . . 36, Dawson-street.
- 1862 Dodd, George (*F.L.M.*),
- 1876 Dorman, John William, . . . Albert-quay, Cork.
- 1881 Doyle, Francis A., . . . Town Hall, Kingstown.
- 1878 Duffin, Wm. E. L'Estrange, . . . Whitechurch House, Cappoquin, Co. Waterford.
- 1868 Dunscombe, Clement, M.A.,  
M.Inst.C.E., . . . City Engineer, Liverpool, W.
- 1836 Farrell, James B., M.Inst.C.E., . . . Glendarra, Wexford.
- 1861 A) FitzGerald, Thomas (*Member of Council*), . . . 85, Gardiner's-place.
- 1872 M) . . .
- 1880 Flemyng, Benjamin F., . . . Blenheim, Glenagarey, Kingstown, and 85, Dawson-street.
- 1874 Galwey, Charles R., . . . Waterford.
- 1875 Geoghegan, Samuel, . . . 81, James'-street, Dublin.  
(*Vice-President*),
- 1877 Glover, Edward, M.A., B.E., . . . County Surveyor's Office, Naas.
- 1849 Gray, Richard A. (*L.M.*), . . . Fortfield House, Upper Rathmines.
- 1874 Greene, John J. F., B.A., . . . North Strand, Drogheda.
- 1881 A) Grierson, Thomas B., . . . 129, Tritonville-road, Sandymount.
- 1886 M) . . .
- 1871 Griffith, John Purser, M.Inst.C.E.  
(*President*), . . . Port and Docks Board, North-wall, Dublin.
- 1875 Harty, Spencer. . . . Melrose, Ranelagh-road, and Engineer's Office, City Hall,  
(*Member of Council*),

## ELECTED

- 1862 Haughton, S. Wilfred, . . . Greenbank, Carlow.
- 1872 Heenan, Robert Henry, . . . Cape Town, South Africa.
- 1875  $\begin{smallmatrix} A \\ M \end{smallmatrix} \}$  Hennessy, Maurice A., . . . 10, Glentworth-street, Limerick.
- 1845 Hill, John, M.Inst.C.E., . . . Co. Surveyor's Office, Ennis.
- 1882 Ivatt, Henry A., (*Member of Council*), . . . St. John's, Island Bridge.
- 1865 Johnston, Henry, . . . 150, Leinster-road, Rathmines.
- 1880 Jones, Stopford, . . . Board of Works, Ballina.
- 1877 Joyce, Arthur Edward, . . . Prospect, Mullingar.
- 1874 Keane, Sir Richard F., Bart., . . . Cappoquin.
- 1858 Kelly, James (*F.L.M.*), . . . Johnstown House, Athlone.
- 1875 Kelly, Michael Alexr. (*F.L.M.*), . . . Essex Lawn, Roscommon.
- 1883 Latimer, John, . . . 41, Clarendon-street, Londonderry.
- 1878 Lawless, Louis J., . . . City Hall, Dublin.
- 1877  $\begin{smallmatrix} A \\ M \end{smallmatrix} \}$  Leonard, Patrick F., . . . 35, Lower Ormond-quay, Dublin.
- 1880  $\begin{smallmatrix} A \\ M \end{smallmatrix} \}$
- 1856 Lewis, William, . . . 43, Dame-street.
- 1874 Longfield, John, . . .
- 1878 Lopdell, John, . . . Church-street, Ennis.
- 1856 Lyons, M. E. (*F.L.M.*), . . . Vera Cruz.
- 1874 Lyster, John Lionel, . . . Stillorgan Cottage, Co. Dublin.
- 1848 Manning, Robert, M.Inst.C.E. (*Past President*), . . . Board of Works, Custom House, Dublin.
- 1884 Manning, William, . . . Kilnamoragh, Donadea, Killocock.
- 1865 Maxwell, W. J., . . . Andreas Hotel, Beyrout, Damascus.

## ELECTED

- 1884 Maxwell, J. Francis, . . . Ballinamore, Co. Leitrim.
- 1860 M'Donnell, Alex., M.Inst.C.E.  
(*Past President*), . . . Saltwell Hall, Gateshead-on-Tyne.
- 1880 M'Donald, Donald, . . . Larne Harbour, Co. Antrim.
- 1879 M'Mullen, Michael Joseph, . . Sun Lodge, Sunday's Well, Cork.
- 1877<sub>A</sub> } M'Swiney, Eugene J. O'B., . . Huelva, Spain.  
1883<sub>M</sub> }
- 1882 Metge, Peter Ponsonby, . . . 9, Harcourt-terrace.
- 1877 Mills, William H., M.Inst.C.E.  
(*Past President*), . . . Nurney, Glenagarey, and Great Northern Railway.
- 1862 Moberly, Charles H. (*F.L.M.*), . . Erith, Kent, S.E.
- 1869<sub>A</sub> } Moore, Joseph Henry, A.M.,  
1874<sub>M</sub> } T.C.D., . . . Navan.
- 1879<sub>A</sub> } Morony, Henry Vereker L.B.E., Board of Works, Dublin.  
1882<sub>M</sub> }
- 1866 Morris, Thos. B., . . . Bombay, and 65, Pembroke-road, Dublin.
- 1881 Moynan, J. Ousley, M.A., . . Co. Surveyor's Office, Longford
- 1883 Mulvany, Christopher, M.A.,  
B.E., . . . Co. Surveyor's Office, Castle-reagh.
- 1882 Myles, Thomas J., B.A., . . Broadstone Terminus, M.G.W. Railway, Ireland.
- 1845 Neville, John (*L.M.*), . . . Jocelyn-street, Dundalk.
- 1878 Nugent, Samuel William (*Member of Council*), . . . Martello House, Kingstown, Co. Dublin.
- 1875 O'Keeffe, Mathias Thomas, . . Brixton, London.
- 1869<sub>A</sub> } Ormsby, Robert Daly, . . . P. W. D., Colombo, Ceylon.  
1876<sub>M</sub> }
- 1856 Osborne, R. B. (*F.L.M.*), . . 302 Walnut-st., Philadelphia, U.S.A.
- 1882 Otway, James, B.A., M.Inst.C.E., Waterford.
- 1881 Park, J. Crawford, . . . The Manse, Dundalk.
- 1874 Pigot, Thomas F., . . . 4, Wellington-road, Dublin.

## ELECTED

- 1861 Price, James, M.Inst.C.E. (*Past Vice-President*), . . . Knocknessin, Greystones, and 44, Harcourt-street, Dublin.
- 1865 Price, W. H., M.Inst.C.E., . . . Kurrachee, India.
- 1880 Robinson, Hercules F. A., . . . Board of Public Works.
- 1884 Ross, William, . . . 66, North Wall, Dublin.
- 1881 Ryan, Edward K., . . . Wexford.
- 1879 Ryan, John H., B.A., M.Inst.C.E., . . . 3, Lr. Merrion-street, Dublin.
- 1875 Sanders, Richard Barnsley, B.E., . . . Cumberland-square, Parsons-town.
- 1872 Scott, William Angel, . . .
- 1882<sub>A</sub> } Shannon, Samuel J., . . . New Ross.  
1887<sub>M</sub> }
- 1881 Shaw, Prosser A. H., . . . 91, Leinster-road, Rathmines.
- 1871 Smith, John Chaloner, M.Inst.C.E. M.R.I.A. (*Member of Council and Hon. Sec.*), . . . St. Helen's, Bray, Co. Wicklow.
- 1861 Smyth, John, jun., M.A., F.C.S., . . . Milltown, near Banbridge.
- 1876 Somerville, Richard N., . . . Ardeevin-place, Galway.
- 1874 Souttar, Robinson, Assoc. M.Inst. C.E., . . . 8, Castle-street, Liverpool.
- 1882 Stewart, Abraham M'Causland, B.E., . . . 20, Pump-street, Derry.
- 1874 Stokes, Henry, . . . Tralee.
- 1857 Stoney, Bindon B., LL.D., M.Inst.C.E., M.R.I.A. (*L.M., Past President*), . . . Port and Docks Board, North Wall, Dublin.
- 1868 Stoney, Edward Waller, M.Inst. C.E. (*F.L.M.*), . . . Madras Railway, Madras.
- 1864 Stoney, F. G. M., . . . India.
- 1873 Stoney, Robert Vesey (*L.M.*), . . . Rosturk Castle, Co. Mayo.
- 1872 Stoney, Thomas Butler (*F.L.M.*), . . . Oakfield, Raphoe, Co. Donegal.
- 1867<sub>A</sub> } Strype, William George,  
1872<sub>M</sub> } M.Inst.C.E., . . . The Murrough, Wicklow.
- 1875 Stuart, Charles M'Donnell, . . .
- 1880 Spence, William, . . . 107, Cork-street, Dublin.

## ELECTED

- 1844 Tate, Alexander (*L.M.*), . . . Longwood, Belfast.  
 1882 Thomson, Frank W., B.E., . . . P.W.D., Deltota, Ceylon.  
 1873 Tighe, James, . . . . . Waterford.  
 1866 Townsend, Edward, M.A., . . . Retreat, Galway.  
 1881 Travers, Thomas, . . . . . Gas Works, Cork.  
 1860 Tuthill, R. R., . . . . . South Africa, Port Elizabeth
- 1865 Waller, Geo. Arth., M.A. (*L.M.*),  
 1862 Walpole, Thomas, . . . . . Windsor Lodge, Seafeld-av.,  
 Monkstown, Co. Dublin.  
 1875 Walsh, Richard Walter, . . . . 10, South Frederick-street, and  
 Alverno, Dalkey.  
 1875 White, Henry Vincent, . . . . . Portarlinton, Queen's Co.  
 1874 Willson, Frederick R. T., B.E., . Prospect, Enniskillen.  
 1874 Wilson, Richard, . . . . . Rose Bank, Ennis.  
 1875 A } Wilson, William W. (*Member*  
 1882 M } *of Council*), . . . . . James's Gate Brewery, Dublin.  
 1876 A } Wise, Berkley D., . . . . . Belfast and County Down  
 1880 M } Railway, Belfast.  
 1871 Wright, John Arthur (*F.L.M.*), . Cadiz Water Works, Sto.  
 Cristo 4, Cadiz.

## ASSOCIATES.

(*Assoc. Inst. C.E.I.*)

- 1884 Anderson, William . . . . . 31, Sackville-street, and 67,  
 Park-avenue, Sandymount.  
 1883 Atkins, Charles Wilson, . . . . Corbally, Limerick.  
 1879 Barnes, Robert Samuel Wemyss . Borough Engineer's Office,  
 Durban, Natal.  
 1880 Bergin, Augustine J., . . . . . Irish Lights Board, Dublin,  
 and 44, Serpentine-avenue,  
 Sandymount.  
 1875 Booth, George, . . . . . 4, Stephen's-green.  
 1875 Courtney, Wm. M'Dougal, M.  
 Inst.C.E., . . . . . Sydney, Australia.

## ELECTED

- 1884 De Burgh, E. Macartney, . . . Union Bank of Australia,  
Sydney, N.S.W.
- 1874 Dixon, Thomas J., . . . Beech Hill, Donnybrook.
- 1883 Evans, James, . . . 27, Rutland-square, Dublin.
- 1877 Fahie, J. Angelo, . . . 23, Leinster-square, Rathmines,  
and 10, Leinster-street.
- 1874 Falkiner, Nathaniel L., . . Port Chalmers, New Zealand.
- 1873 Ferguson, William D., M.A.,  
Assoc.M. Inst.C.E., . . Harbour Board, Wellington,  
New Zealand.
- 1874 Fitt, Decimus, . . . Newport Iron Works, New-  
port, Monmouth.
- 1881 Fleming, Henry, . . . Chicago, U.S.A.
- 1884 Forster, John, . . . 14, St. Andrew-street, Dublin.
- 1873 Fry, William Arthur, . . Ballymena, Co. Antrim.
- 1861 Geoghegan, Charles (*Member of*  
*Council*), . . . 205, Great-Brunswick-street.
- 1885 Gill, Robert P., . . . Co. Surveyor's Office, Nenagh.
- 1878 Gray, Edwin, . . .
- 1880 Gray, Robert D. W., . . Fortfield House, Rathmines.
- 1879 Gray, William Armroyde, . . New York.
- 1887 Green, John M. S., . . . 88, Leeson-street, Lower.
- 1886 Hade, William P., . . . Dublin-street, Carlow.
- 1885 Harton, Henry T., . . . 3, Nassau-street, and 63,  
Strand-road, Sandymount.
- 1881 Holmes, John, . . . 11, Fleet-street.
- 1875 Holt, Edward G., M.A., . . Dublin.
- 1880 Long, Ardagh E., B.A.,  
A.R.I.N.A., . . . 162, Ellison-street, Jarrow-on-  
Tyne.
- 1885 Maguire, William R., . . . Tower Hill, Dalkey, 10, Daw-  
son-street.
- 1867 Martin, Charles E., . . . 82, North Wall.



## ELECTED

- 1863 Martin, Thomas S. (*Member of Council*), . . . . 82, North Wall.
- 1882 M'Mullen, James F., . . . . 34, Mary-street, Cork.
- 1880 Moyers, George, LL.D., . . . . 8, Vesey-place, Kingstown.
- 1881 Murphy, William, M.P., . . . . Dartry, Rathmines.
- 1886 Murphy, Joseph P., . . . . 2 Trinity-street.
- 1881 O'Toole, James, . . . . Wellington-terrace, Shanikhl, Cork.
- 1883 Pakenham, Frederick E. S., . . Board of Works, Ballina.
- 1861 Patterson, Benjamin T., . . . . 11, Leinster-street, Dublin.
- 1883 Purcell, Marmaduke, . . . . 71, Harcourt-street, Dublin.
- 1885 Purser, J. Graham, . . . . 52, Sackville-street, Upper.
- 1874 Ross, George Murray, . . . . Abbey-street, Dublin.
- 1887 Rochford, John, . . . . Summerhill, Kingstown.
- 1885 Ruthven, John A. C., . . . . 50 Lower Gardiner-street, Dublin.
- 1885 Ryder, Arthur G., . . . . Connorree House, Ovoca.
- 1881 Simpson, John, . . . . 54, Middle Abbey-st., Dublin.
- 1881 Stanfield, John, . . . .
- 1881 Smyth, Richard O'B., . . . . 2, Kenilworth-square, Rathgar.
- 1875 Wardrop, William, . . . . Ailesbury-road, Donnybrook.
- 1887 Watson, Charles W., . . . . 2, Seapoint-terrace, Monks-town.
- 1874 Wigham, John R., . . . . 33, Capel-street, Dublin.
- 1871 Wilson, Charles Monck, . . . . Rose Villa, North Strand, Limerick.
- 1867 Woodward, Richard Caleb, . . Brisbane, Queensland.
- 1881 Worthington, Robert, . . . . Salmon Pool House, Island Bridge.

NOTE—*L.M.*, Life Member—*F.L.M.*, Foreign Life Member.

